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Katsumura et al.

(10) **Patent No.: US 9,457,562 B2**
(45) **Date of Patent: Oct. 4, 2016**

(54) **LIQUID EJECTION DEVICE AND DUMMY JET METHOD**

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(72) Inventors: **Manabu Katsumura**, Kanagawa (JP); **Tsuyoshi Mita**, Kanagawa (JP)

(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/837,225**

(22) Filed: **Aug. 27, 2015**

(65) **Prior Publication Data**

US 2015/0360464 A1 Dec. 17, 2015

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2014/058123, filed on Mar. 24, 2014.

(30) **Foreign Application Priority Data**

Mar. 29, 2013 (JP) 2013-073414
Jun. 28, 2013 (JP) 2013-137026

(51) **Int. Cl.**
B41J 29/38 (2006.01)
B41J 2/045 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B41J 2/0453*** (2013.01); ***B41J 2/14233*** (2013.01); ***B41J 2/16508*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B41J 2/04581; B41J 2/04588; B41J 2/04596; B41J 2/04541; B41J 2/0451; B41J 2202/12; B41J 2202/20; B41J 2202/21; B41J 2/045; B41J 2/0453; B41J 2/14233; B41J 2/1714
USPC 347/9–12, 14, 68
See application file for complete search history.

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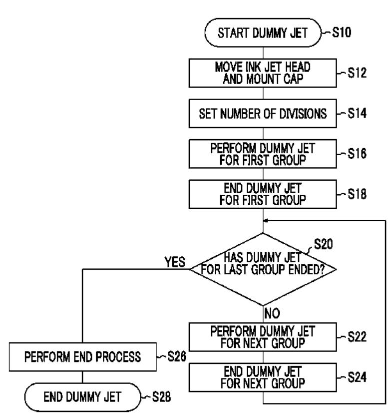
(Continued)

Primary Examiner — Jannelle M Lebron
(74) *Attorney, Agent, or Firm* — Studebaker & Brackett PC

(57) **ABSTRACT**

A liquid ejection device includes an ink jet head in which a plurality of nozzle portions are arranged in a matrix; a plurality of pressurizing elements that generate an ejection force; and a driving voltage supply unit that supplies a driving voltage to the pressurizing elements. In the device, the ink jet head is provided with supply flow paths, the nozzle portions which are supplied with the liquid from the same the supply flow path are divided into two or more groups, the driving voltage supply unit supplies an ejection driving voltage for ejecting the liquid to each of the groups when a dummy jet is performed, and during a period of time when the dummy jet is performed for one group, the driving voltage supply unit supplies a non-ejection driving voltage for preventing the liquid from being ejected to the other groups.

14 Claims, 34 Drawing Sheets



(51) **Int. Cl.**

B41J 2/17	(2006.01)
B41J 2/14	(2006.01)
B41J 2/165	(2006.01)

(52) **U.S. Cl.**

CPC ***B41J2/16526*** (2013.01); ***B41J 2/16585*** (2013.01); ***B41J 2/1714*** (2013.01); *B41J 2002/14459* (2013.01); *B41J 2002/1657* (2013.01); *B41J 2202/12* (2013.01); *B41J 2202/20* (2013.01); *B41J 2202/21* (2013.01)

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An Office Action; "Notification of Reasons for Refusal" issued by the Japanese Patent Office on Jan. 28, 2016, which corresponds to Japanese Patent Application No. 2013-137026 and is related to U.S. Appl. No. 14/837,225; with English language translation.

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FIG. 1

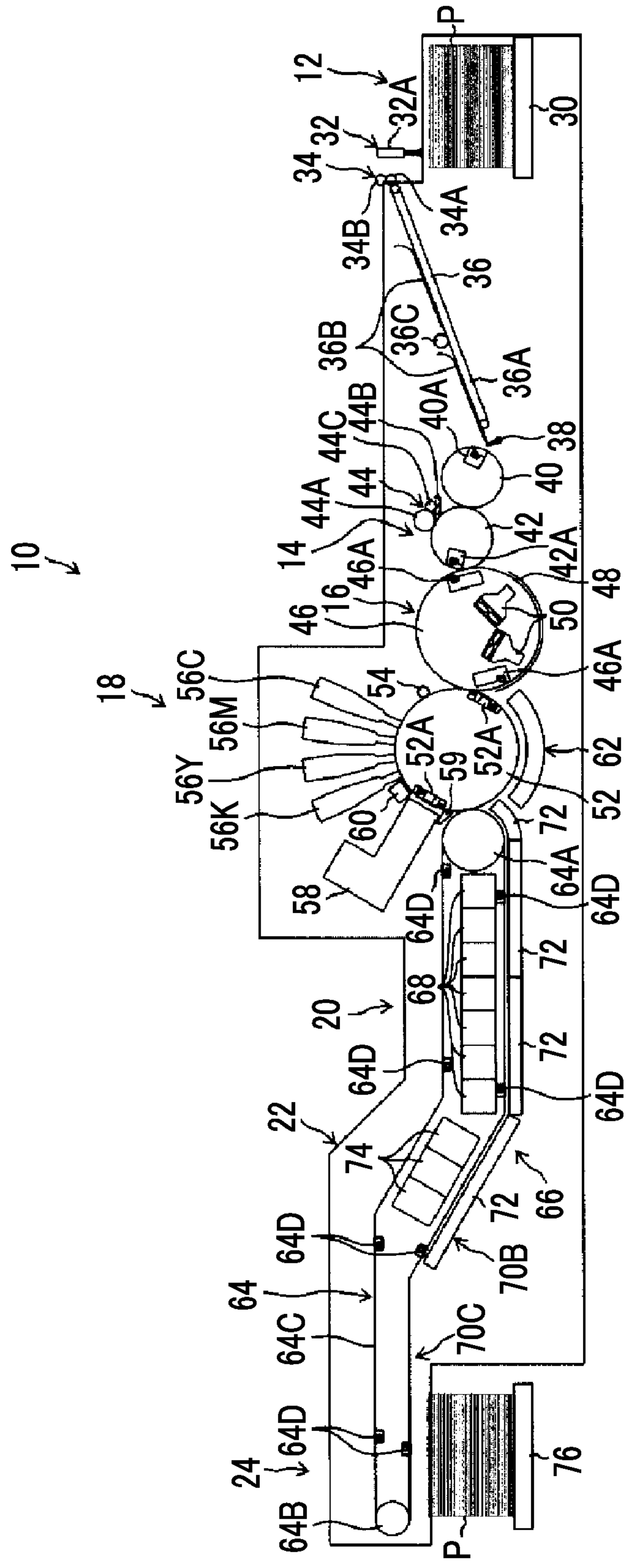

10
12
P
32A
32
34
34A
34B
30
36
36B
36C
36A
38
40A
40
44B
44C
44
44A
42
42A
14
46A
16
46
48
50
46A
18
56C
56M
56Y
56K
54
52A
59
52A
60
62
52
72
58
64A
64D
64D
68
20
72
72
64D
64D
22
74
72
66
64D
70B
64
64C
70C
64D
64D
24
76
64B
P

FIG. 2

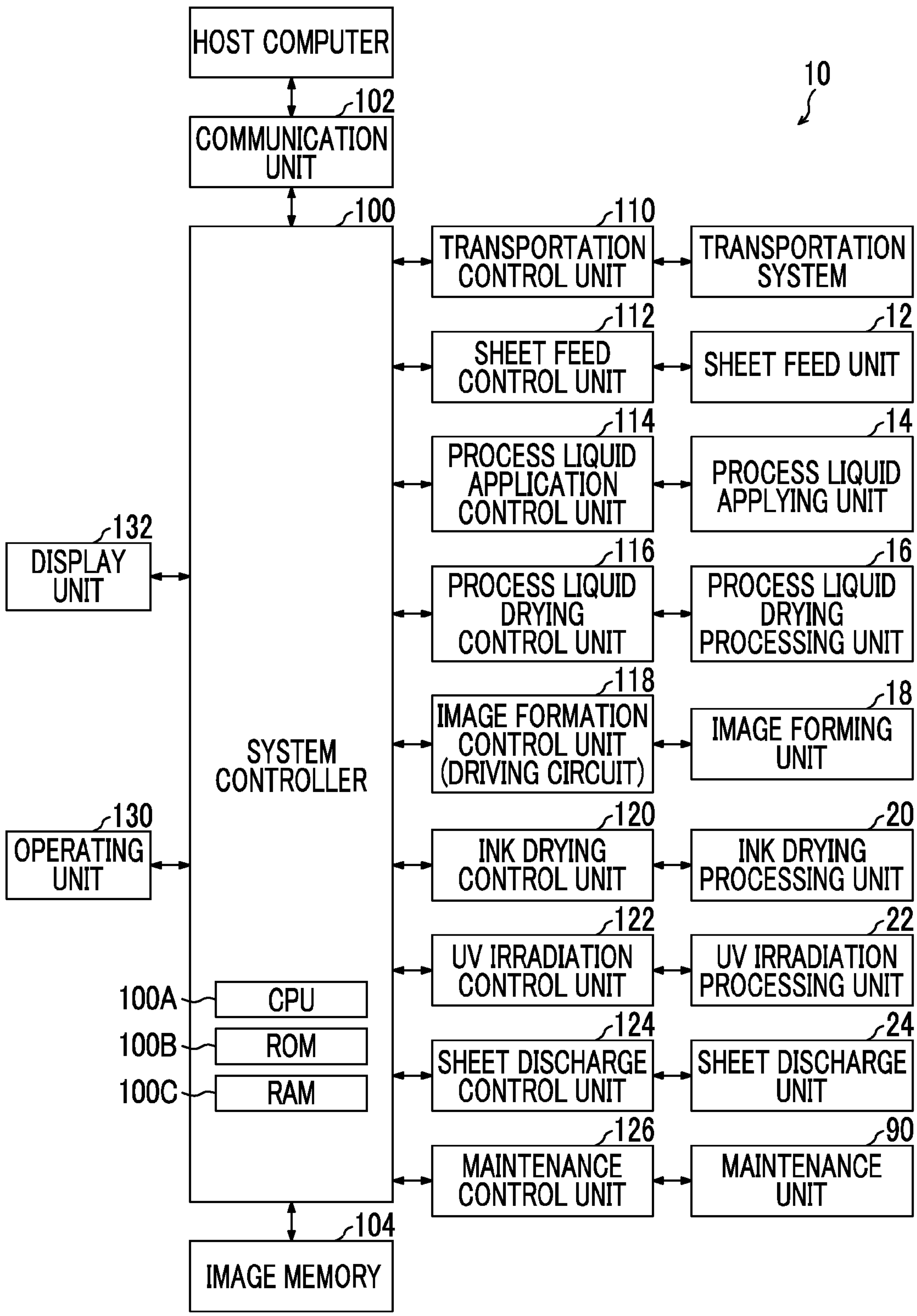

HOST COMPUTER
102
COMMUNICATION UNIT
100
SYSTEM CONTROLLER
100A
CPU
100B
ROM
100C
RAM
104
IMAGE MEMORY
132
DISPLAY UNIT
130
OPERATING UNIT
10
110
TRANSPORTATION CONTROL UNIT
TRANSPORTATION SYSTEM
112
SHEET FEED CONTROL UNIT
12
SHEET FEED UNIT
114
PROCESS LIQUID APPLICATION CONTROL UNIT
14
PROCESS LIQUID APPLYING UNIT
116
PROCESS LIQUID DRYING CONTROL UNIT
16
PROCESS LIQUID DRYING PROCESSING UNIT
118
IMAGE FORMATION CONTROL UNIT (DRIVING CIRCUIT)
18
IMAGE FORMING UNIT
120
INK DRYING CONTROL UNIT
20
INK DRYING PROCESSING UNIT
122
UV IRRADIATION CONTROL UNIT
22
UV IRRADIATION PROCESSING UNIT
124
SHEET DISCHARGE CONTROL UNIT
24
SHEET DISCHARGE UNIT
126
MAINTENANCE CONTROL UNIT
90
MAINTENANCE UNIT

FIG. 3

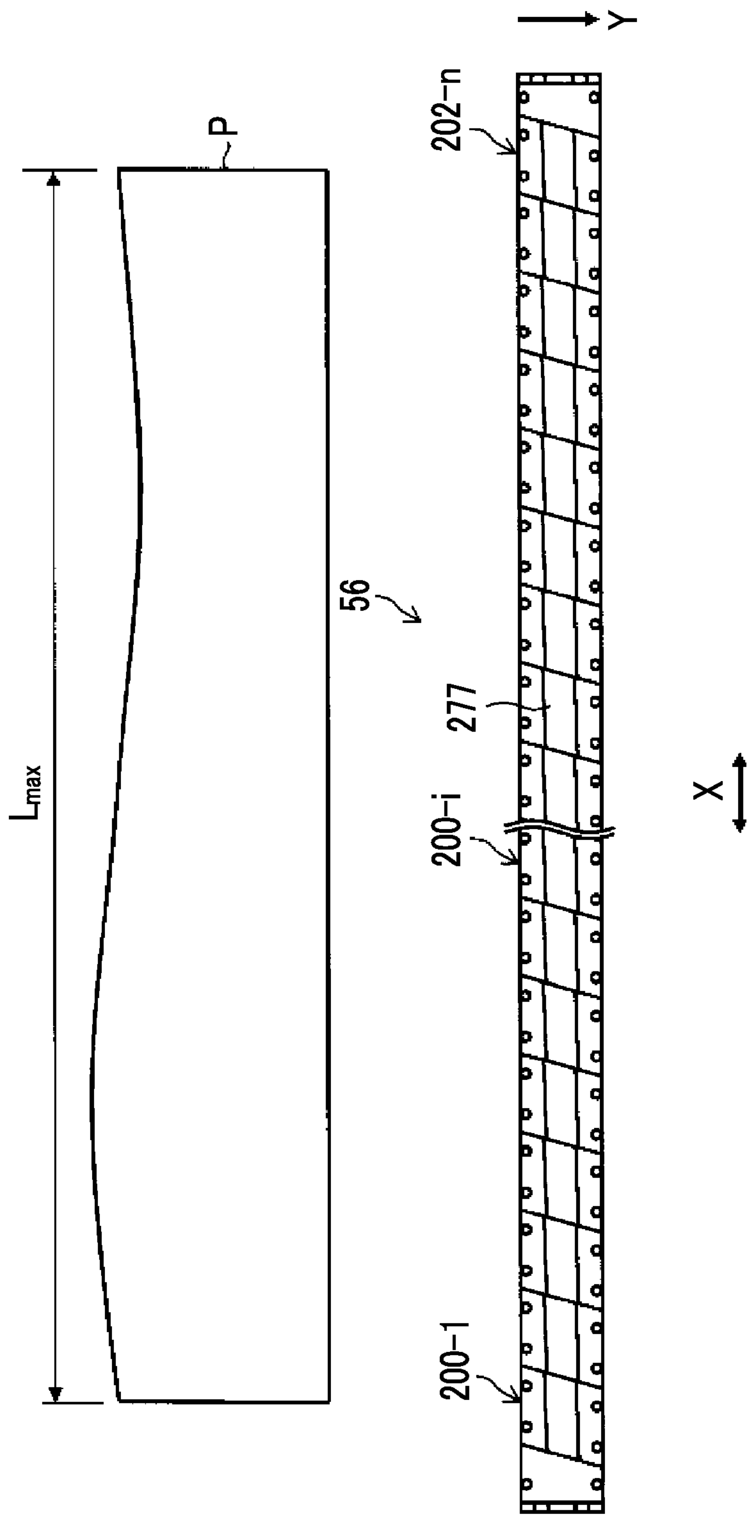


FIG. 4

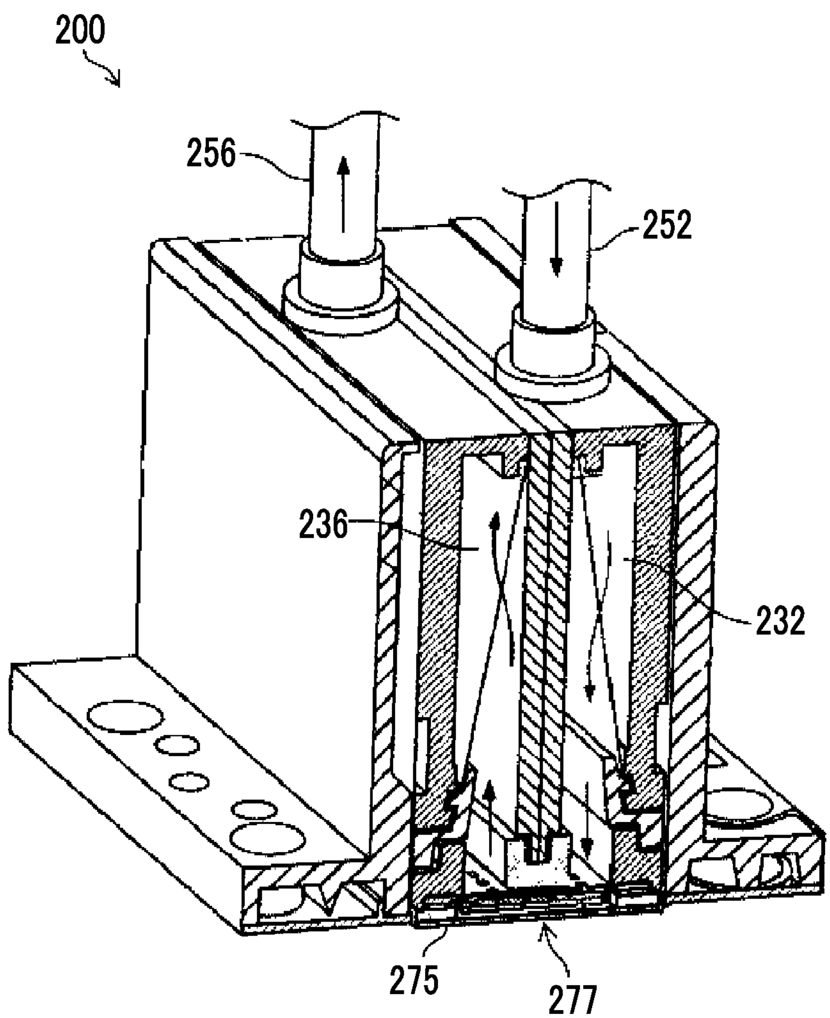
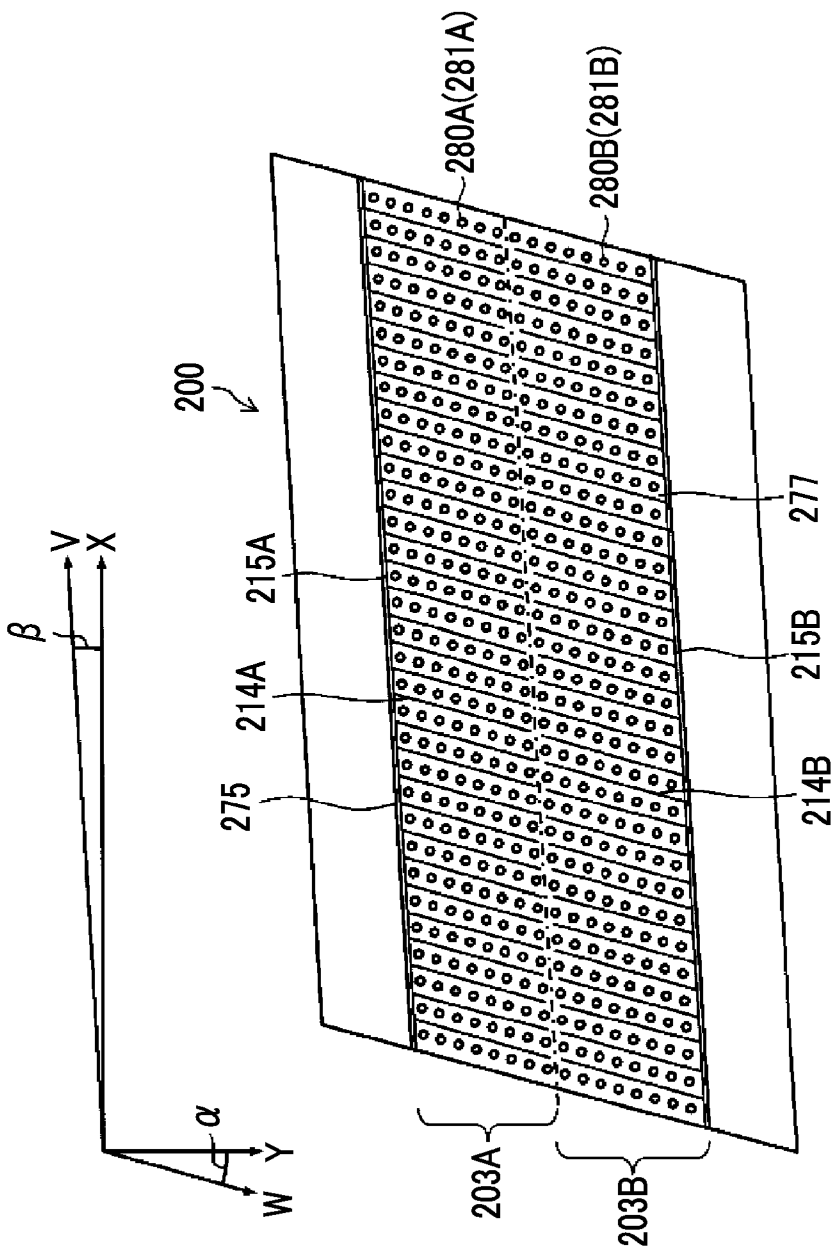


FIG. 5



200
280A(281A)
280B(281B)
277
215A
215B
214A
214B
275
203A
203B
V
X
Y
W
α
β

FIG. 6

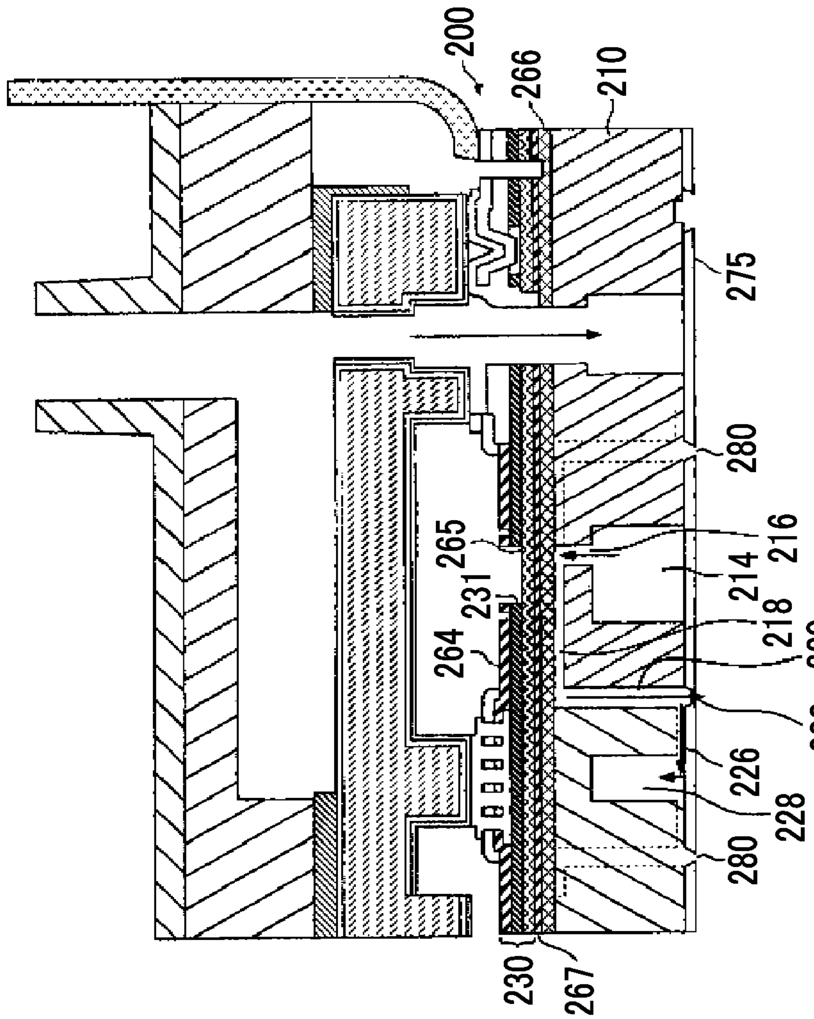

200
266
210
275
280
265
231
264
216
214
218
220
280
226
228
280
230
267

FIG. 7

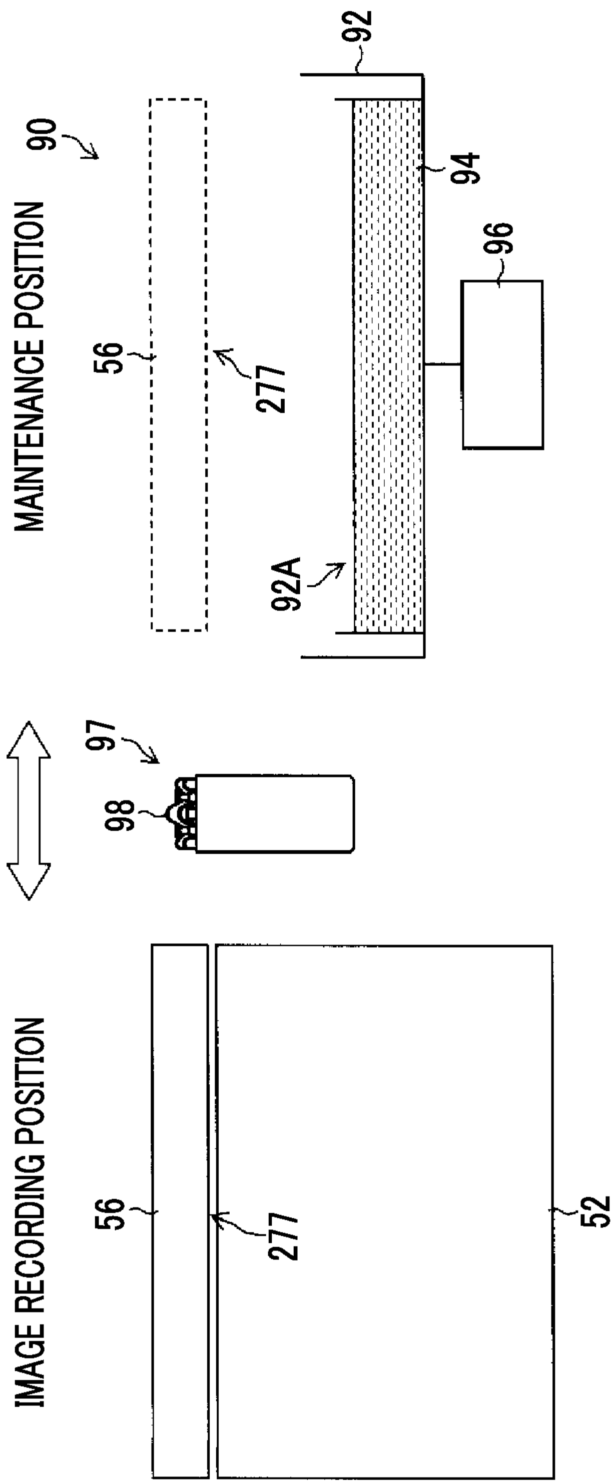

MAINTENANCE POSITION
90
92
94
96
56
277
92A
97
98
IMAGE RECORDING POSITION
56
277
52

FIG. 8

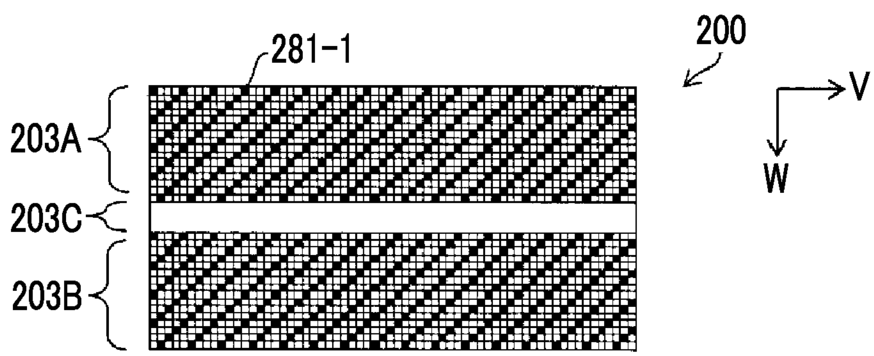


FIG. 9

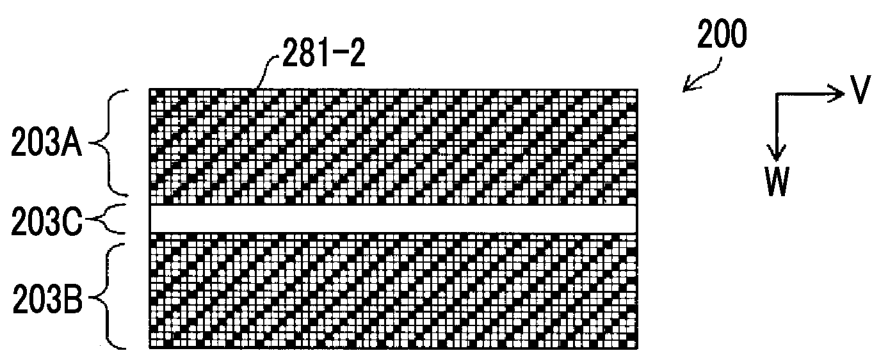


FIG. 10

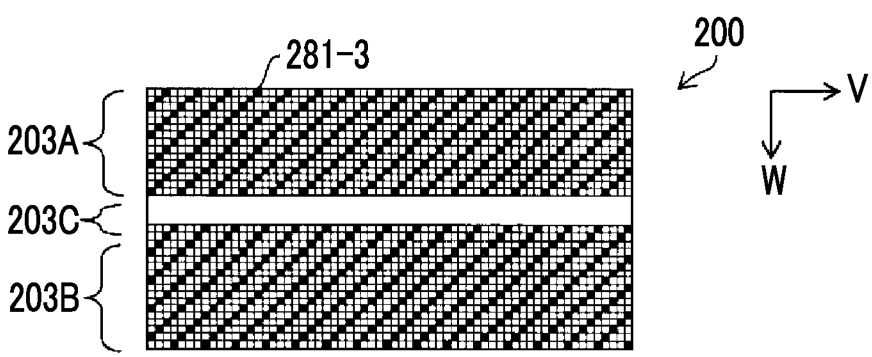


FIG. 11

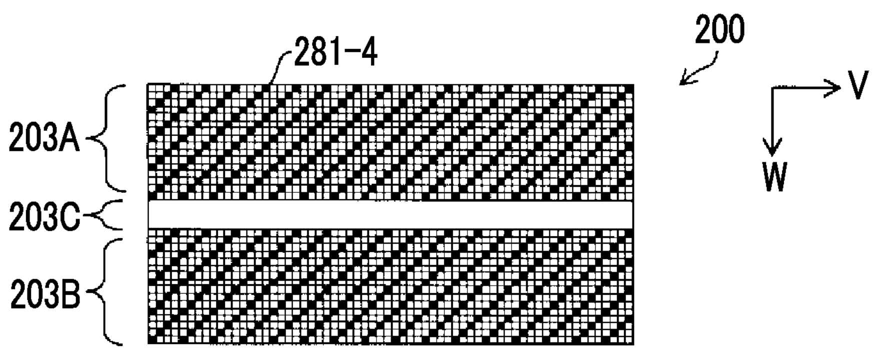


FIG. 12

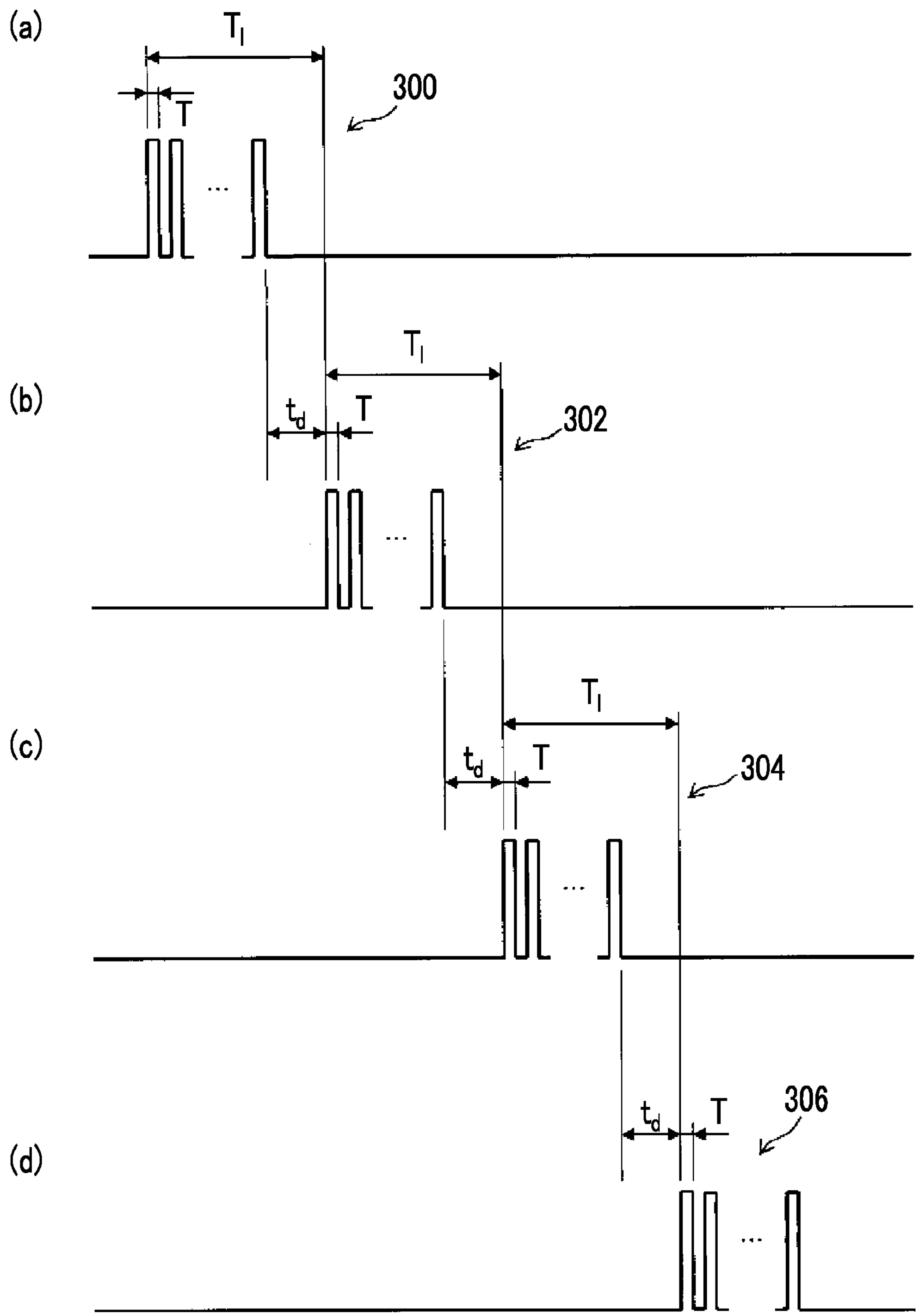


FIG. 13A

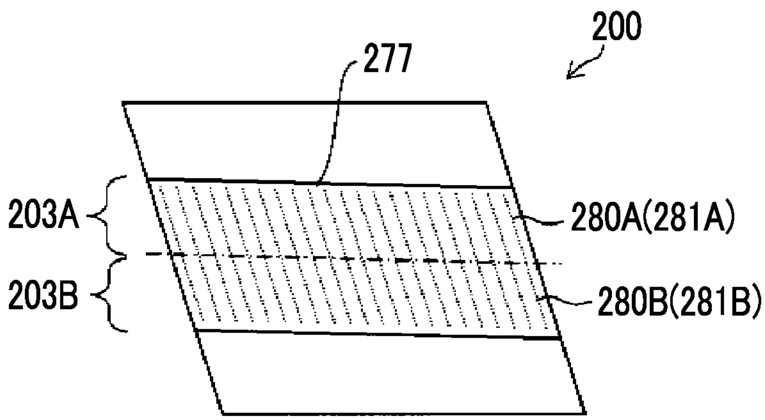


FIG. 13B

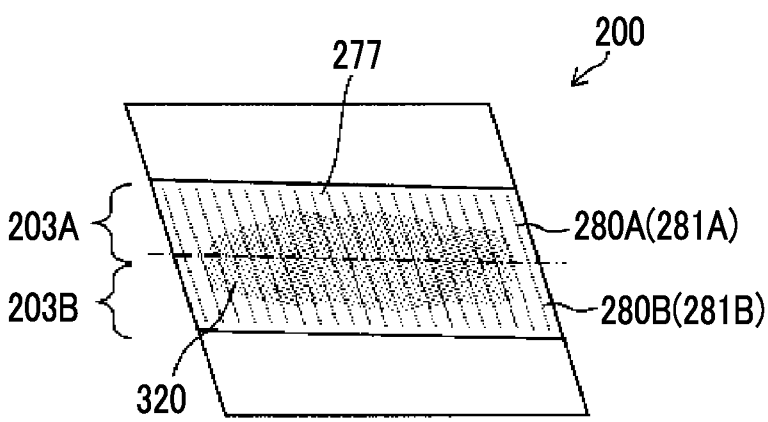


FIG. 14

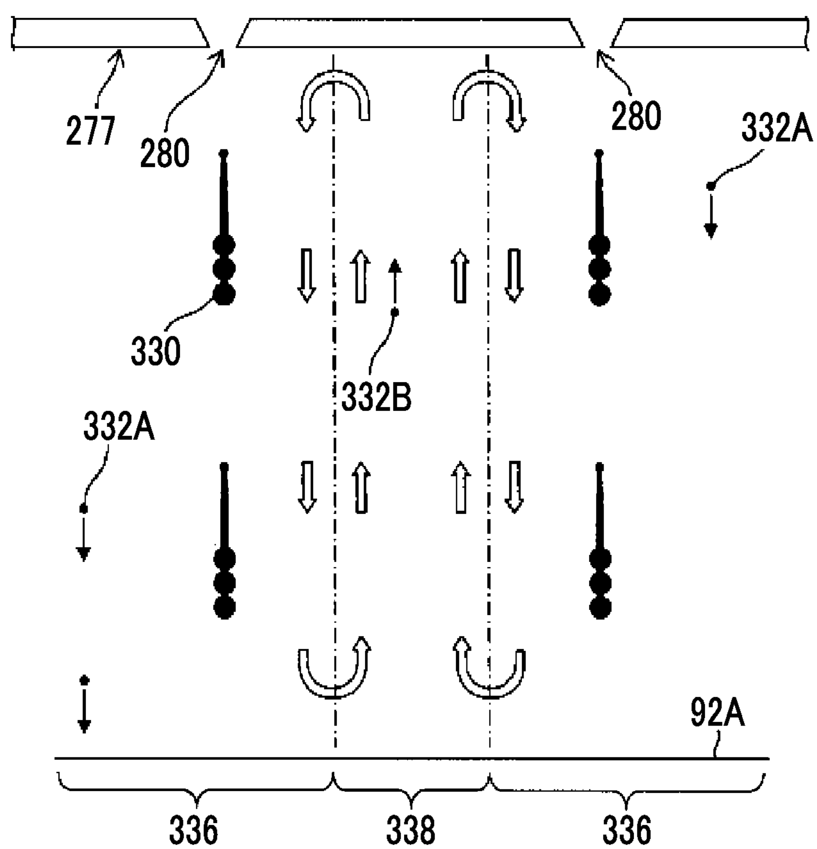


FIG. 15

kHz	EVALUATION OF AMOUNT OF MIST ATTACHED
1	BAD
2	BAD
5	BAD
10	GOOD
17	GOOD
25	GOOD
29	GOOD

FIG. 16

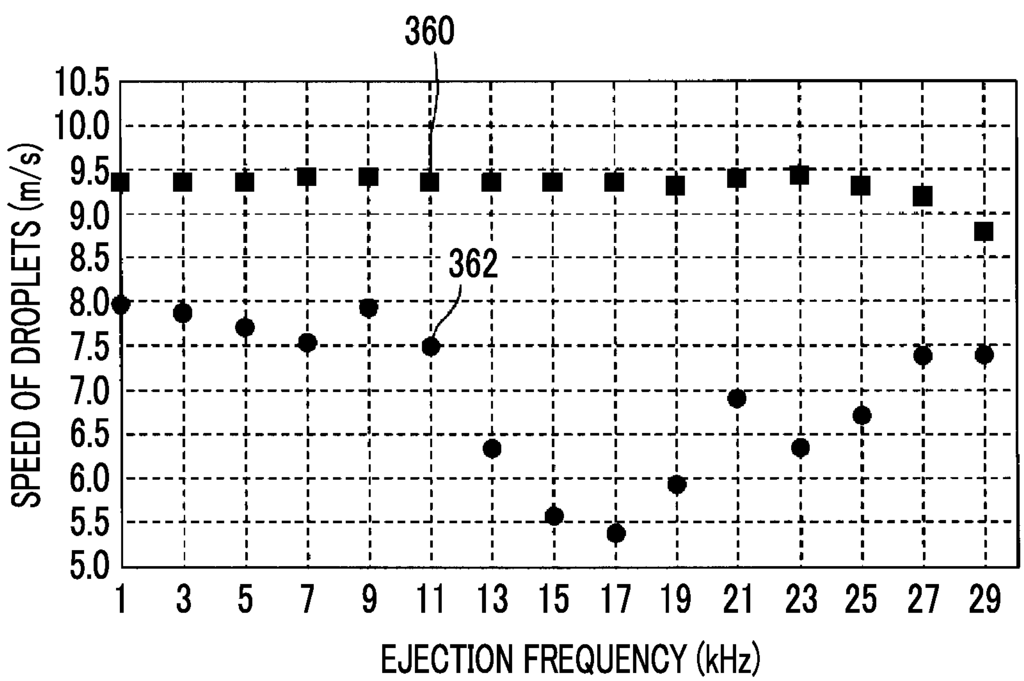

360
362
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
SPEED OF DROPLETS (m/s)
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
EJECTION FREQUENCY (kHz)

FIG. 17

THROW DISTANCE (mm)	EVALUATION OF AMOUNT OF MIST ATTACHED
3.4	GOOD
4.4	GOOD
5.4	GOOD
6.4	BAD
8.4	BAD

FIG. 18A

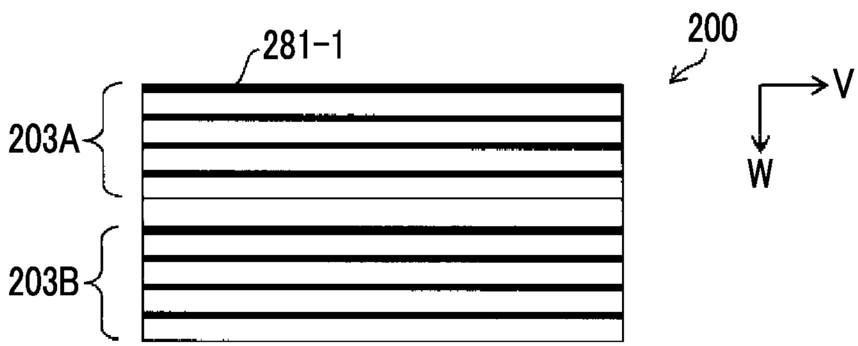


FIG. 18B

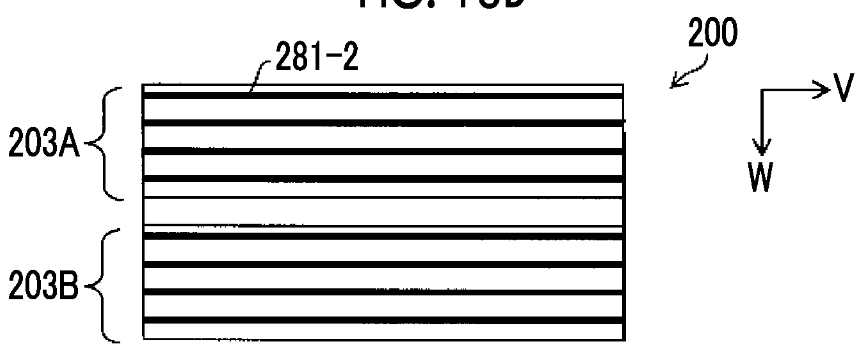


FIG. 18C

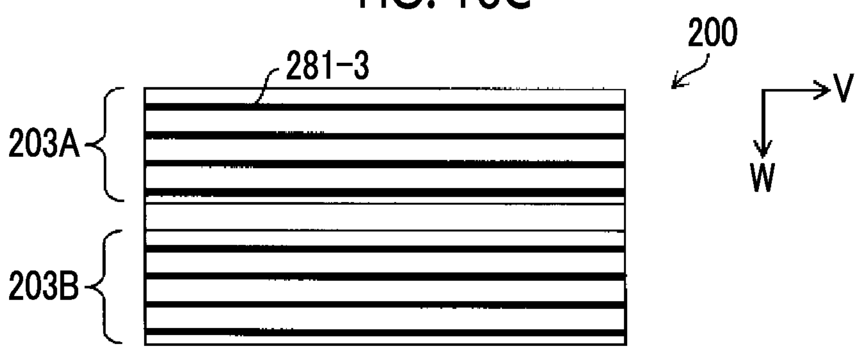


FIG. 18D

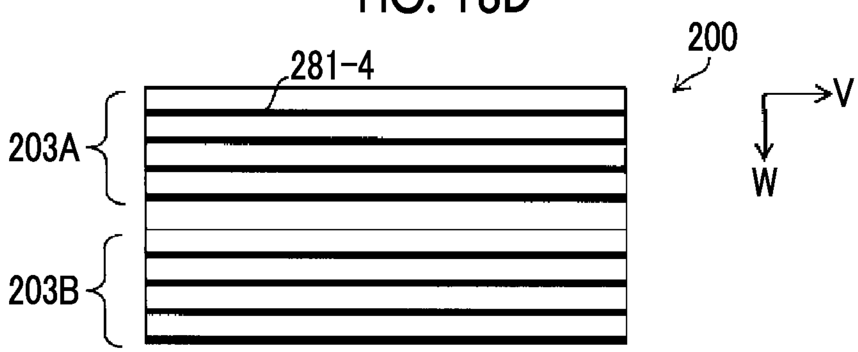


FIG. 19

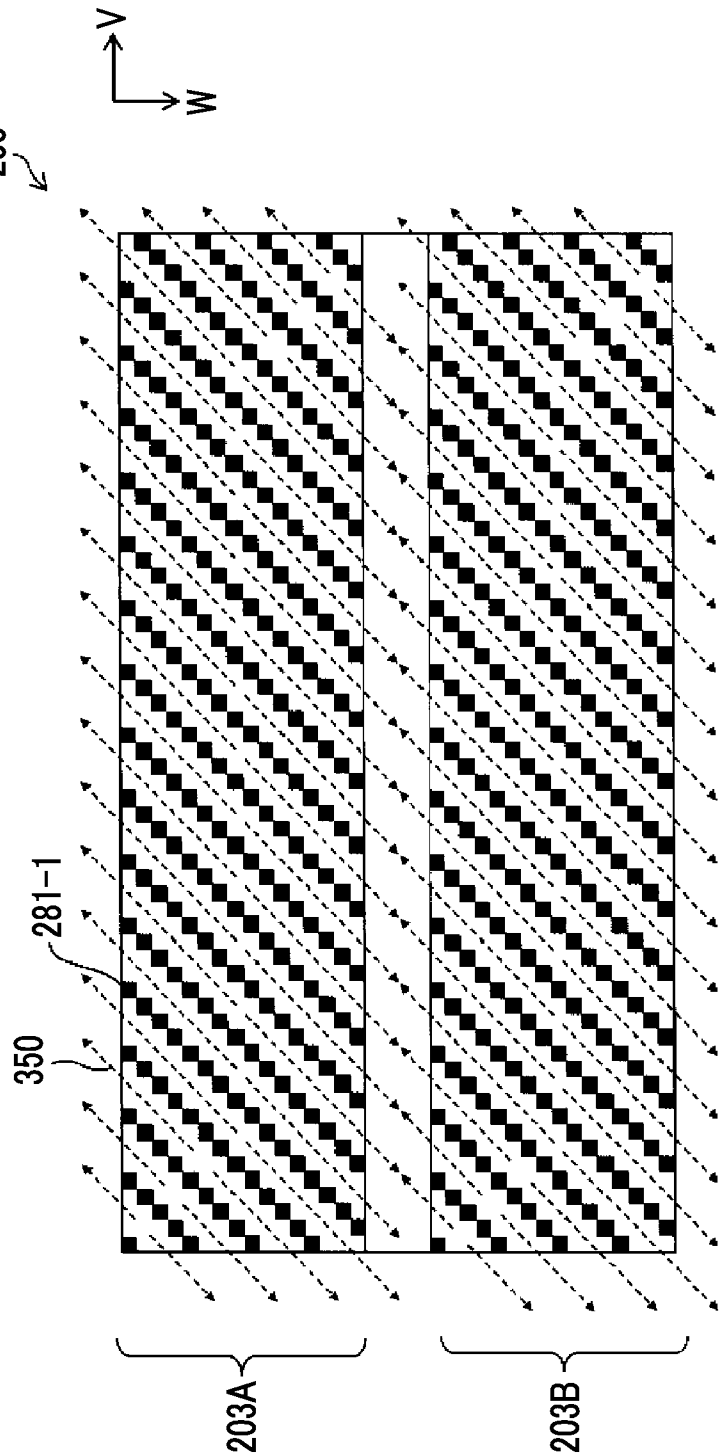


FIG. 20

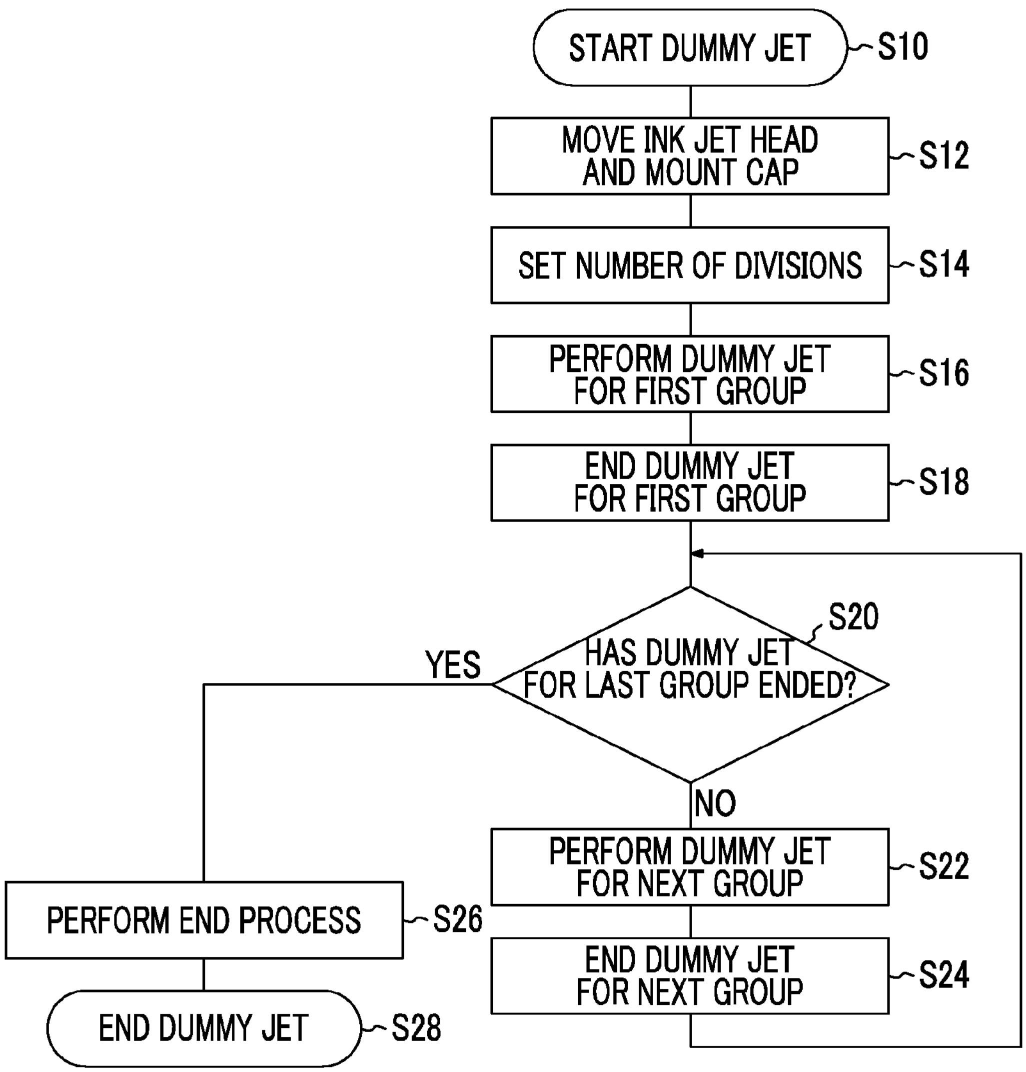

START DUMMY JET
S10
MOVE INK JET HEAD AND MOUNT CAP
S12
SET NUMBER OF DIVISIONS
S14
PERFORM DUMMY JET FOR FIRST GROUP
S16
END DUMMY JET FOR FIRST GROUP
S18
HAS DUMMY JET FOR LAST GROUP ENDED?
S20
YES
NO
PERFORM DUMMY JET FOR NEXT GROUP
S22
END DUMMY JET FOR NEXT GROUP
S24
PERFORM END PROCESS
S26
END DUMMY JET
S28

FIG. 21

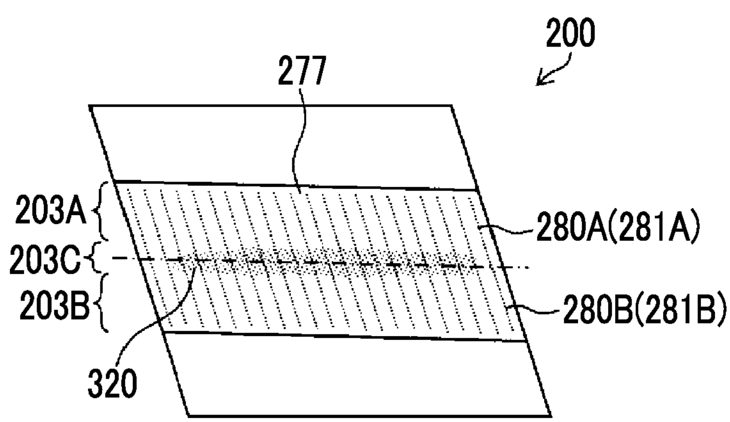


FIG. 22

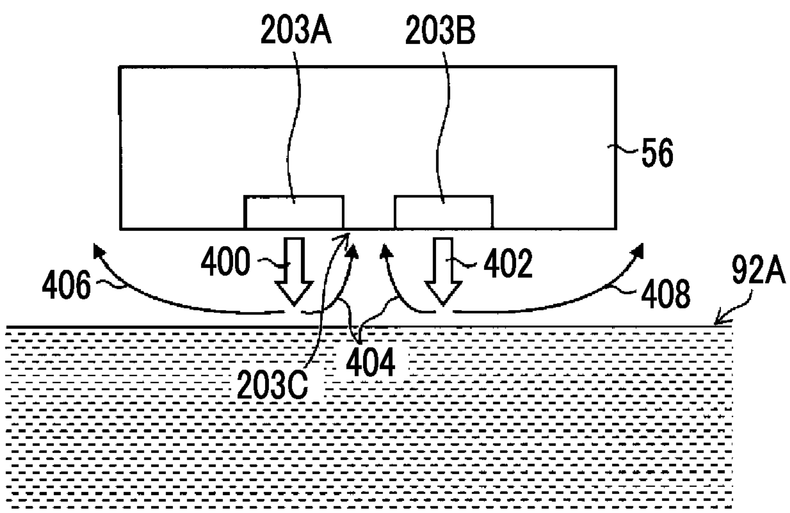


FIG. 23A

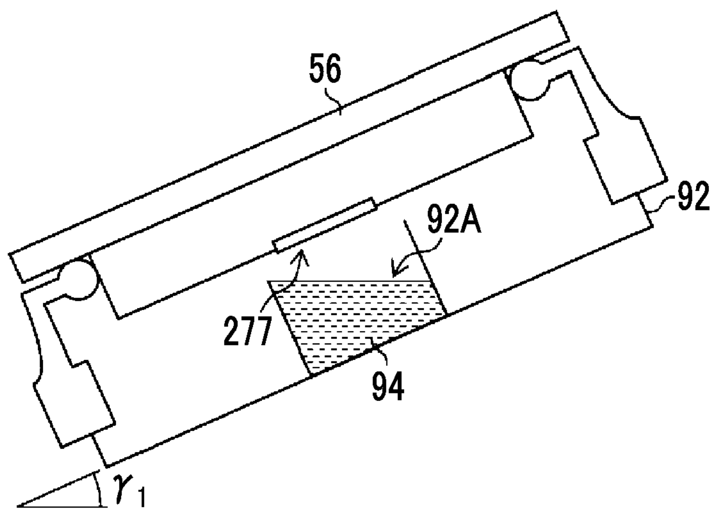


FIG. 23B

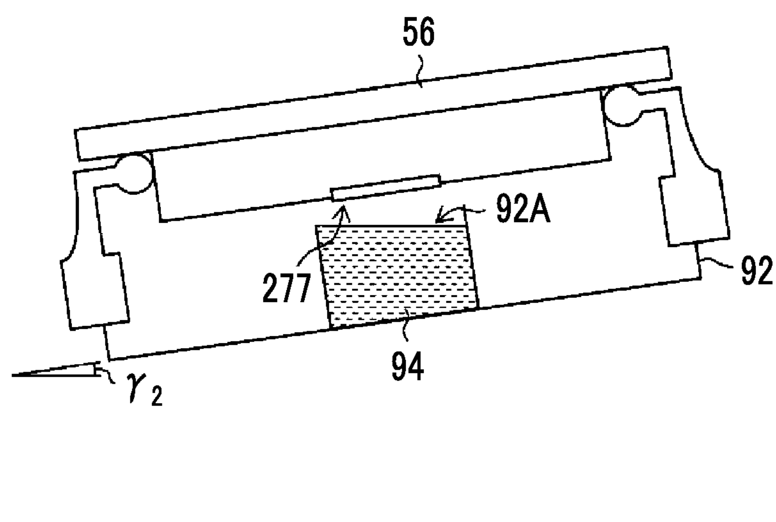


FIG. 24

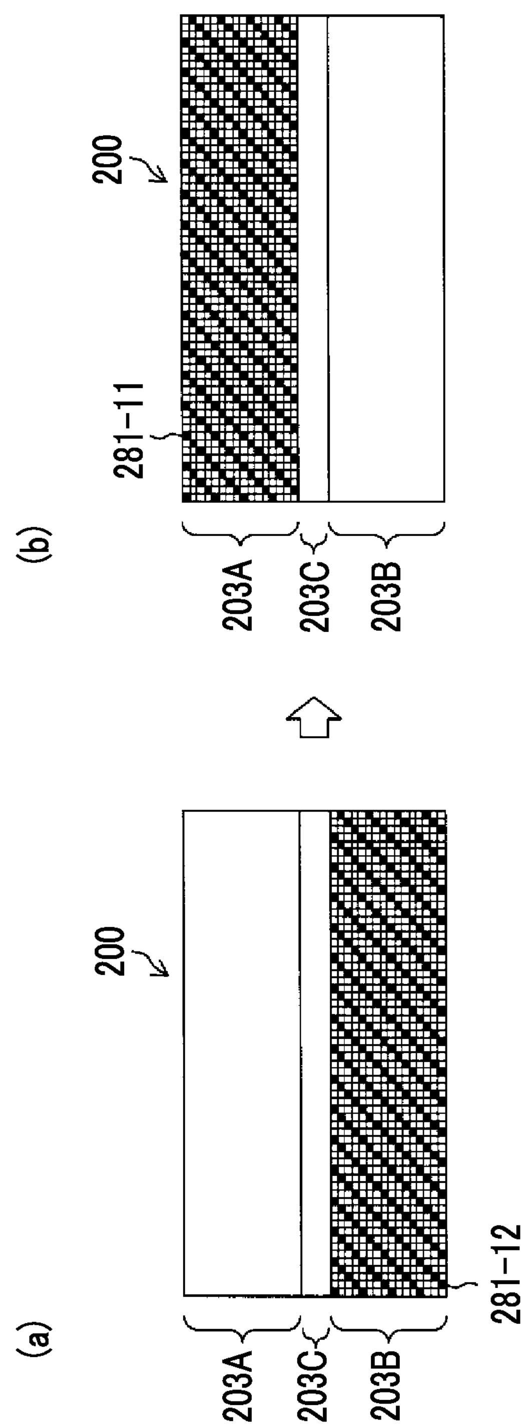


FIG. 25

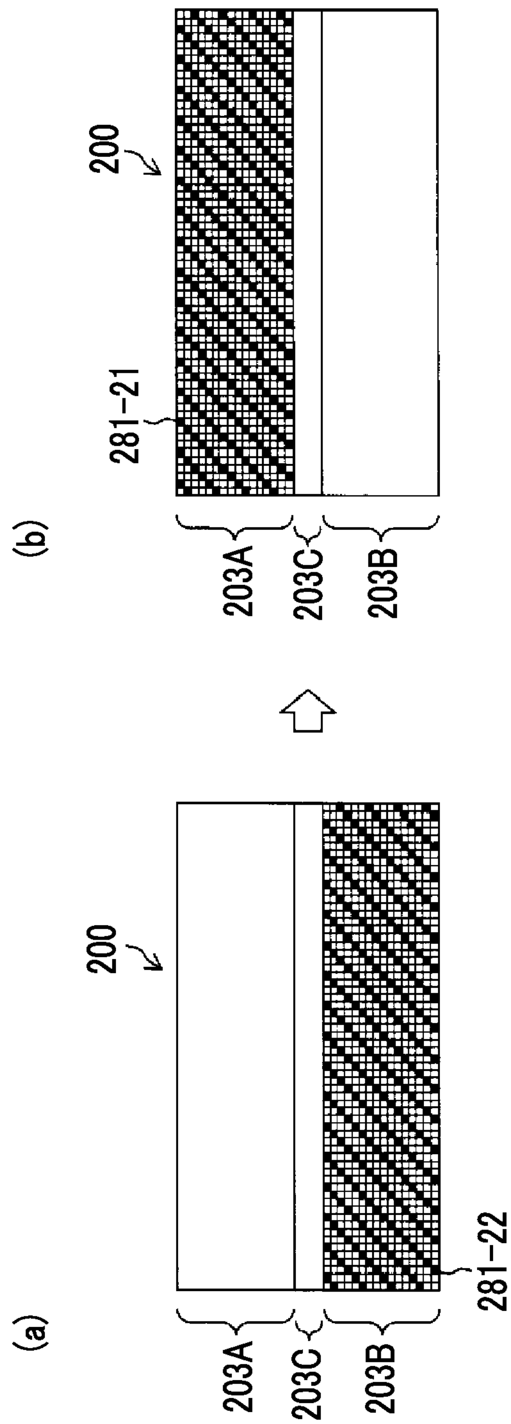


FIG. 26

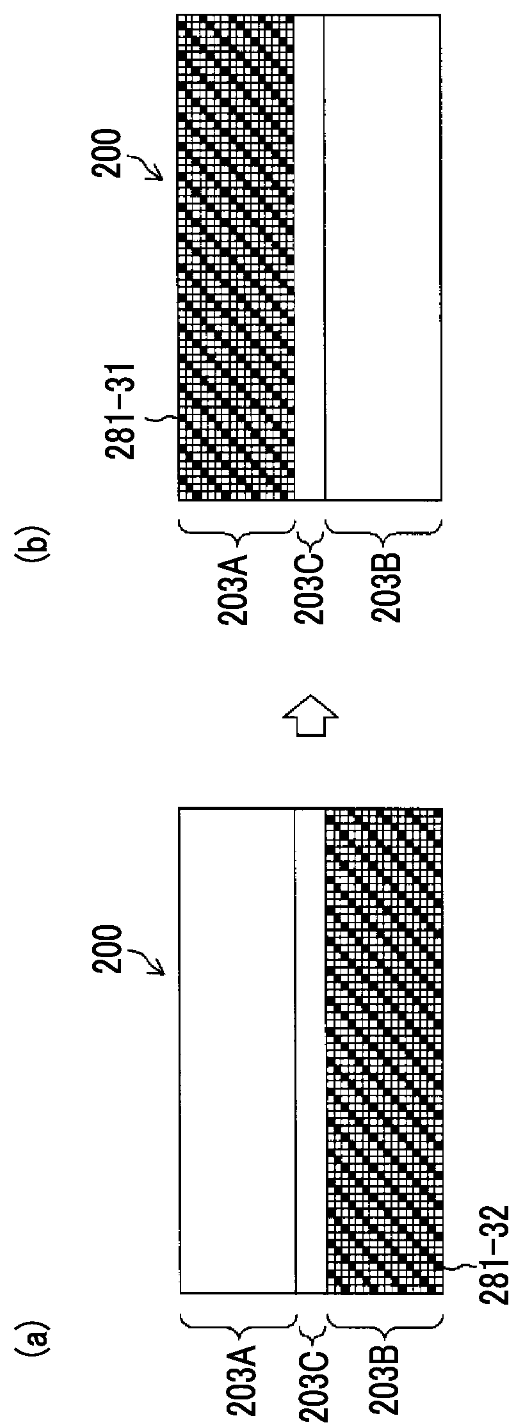


FIG. 27

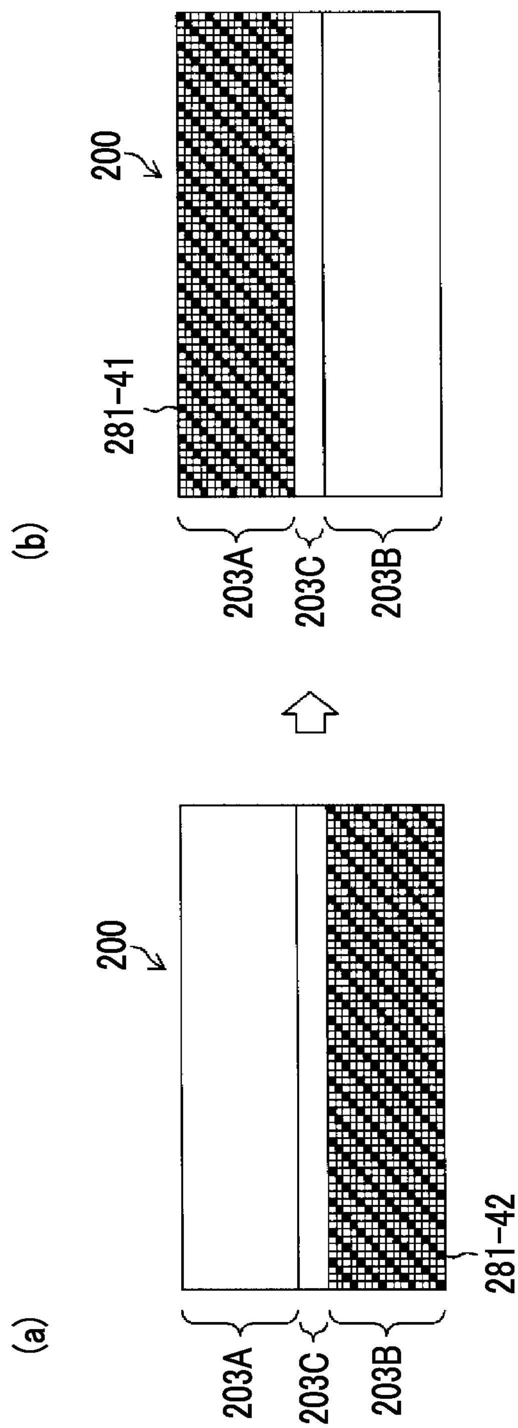


FIG. 28A

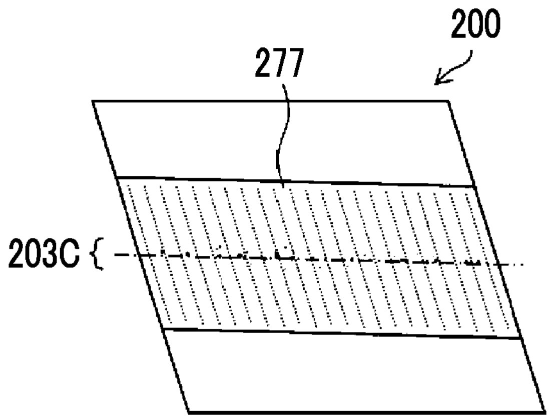


FIG. 28B

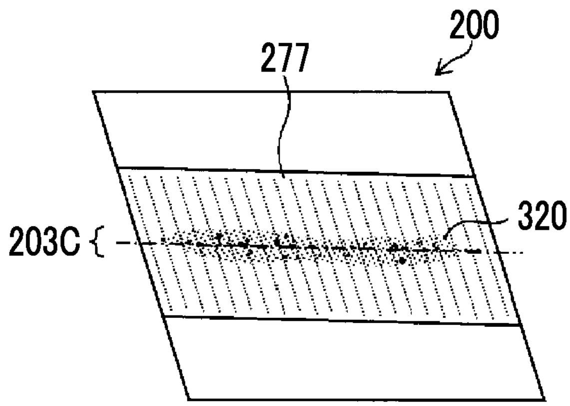


FIG. 28C

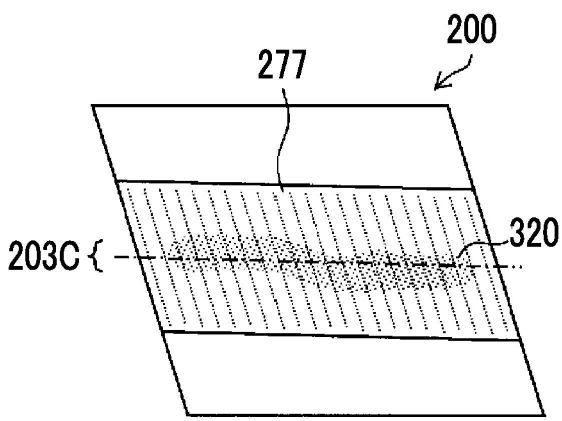


FIG. 29

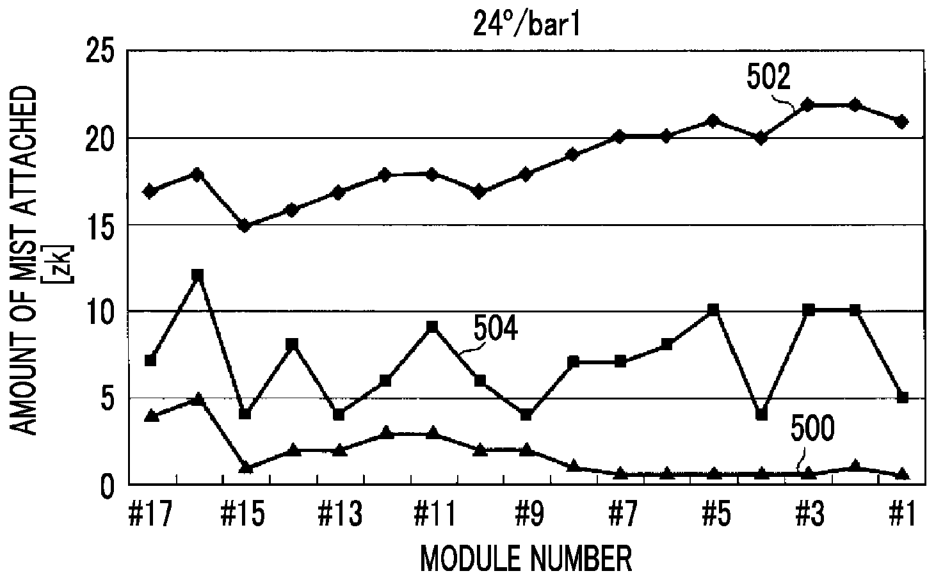

24°/bar1
25
20
15
10
5
0
AMOUNT OF MIST ATTACHED [zk]
502
504
500
#17
#15
#13
#11
#9
#7
#5
#3
#1
MODULE NUMBER

FIG. 30A

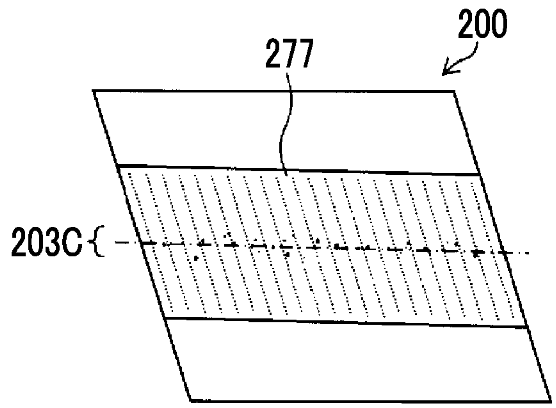


FIG. 30B

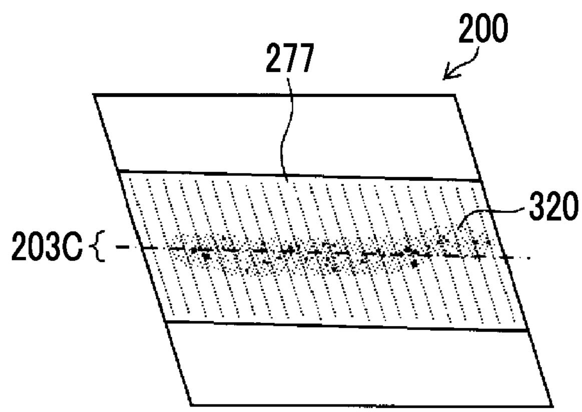


FIG. 30C

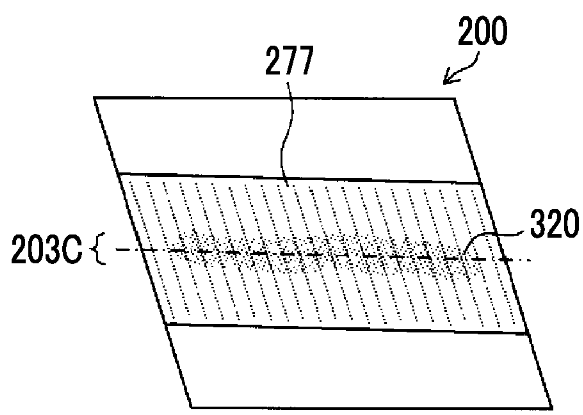


FIG. 31

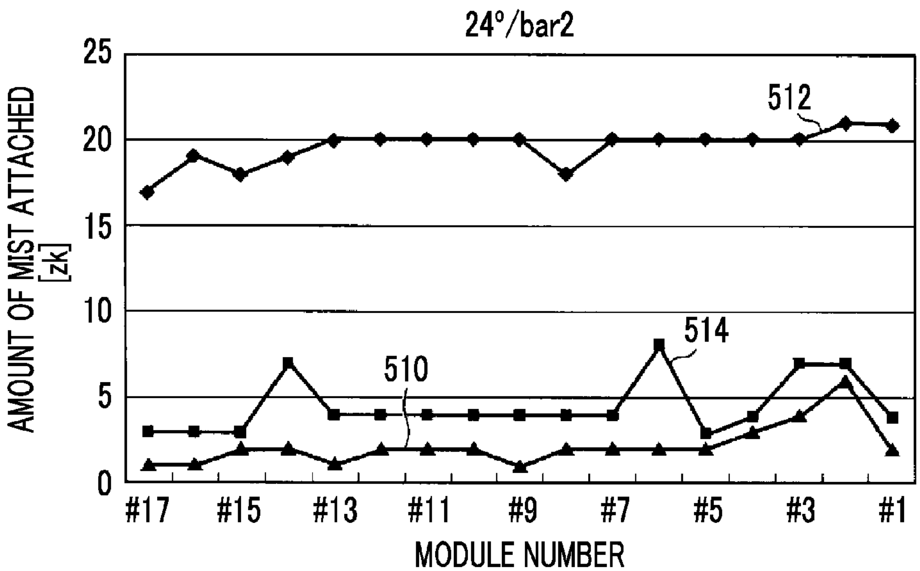

24°/bar2
25
20
15
10
5
0
AMOUNT OF MIST ATTACHED [zk]
512
514
510
#17
#15
#13
#11
#9
#7
#5
#3
#1
MODULE NUMBER

FIG. 32

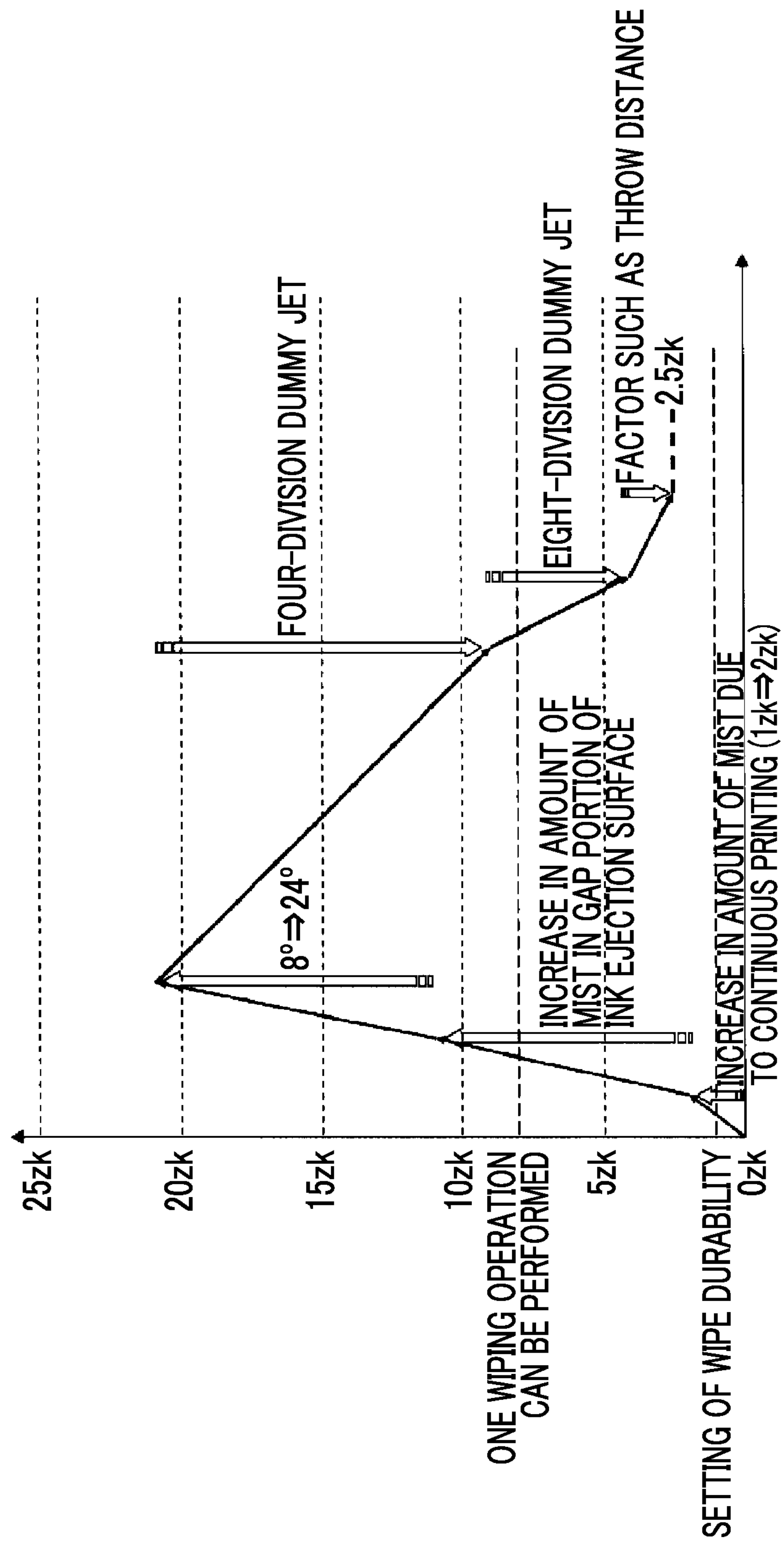

25zk
20zk
15zk
10zk
5zk
0zk
ONE WIPING OPERATION CAN BE PERFORMED
SETTING OF WIPE DURABILITY
INCREASE IN AMOUNT OF MIST DUE TO CONTINUOUS PRINTING (1zk⇒2zk)
INCREASE IN AMOUNT OF MIST IN GAP PORTION OF INK EJECTION SURFACE
8°⇒24°
FOUR-DIVISION DUMMY JET
EIGHT-DIVISION DUMMY JET
FACTOR SUCH AS THROW DISTANCE
-2.5zk

FIG. 33

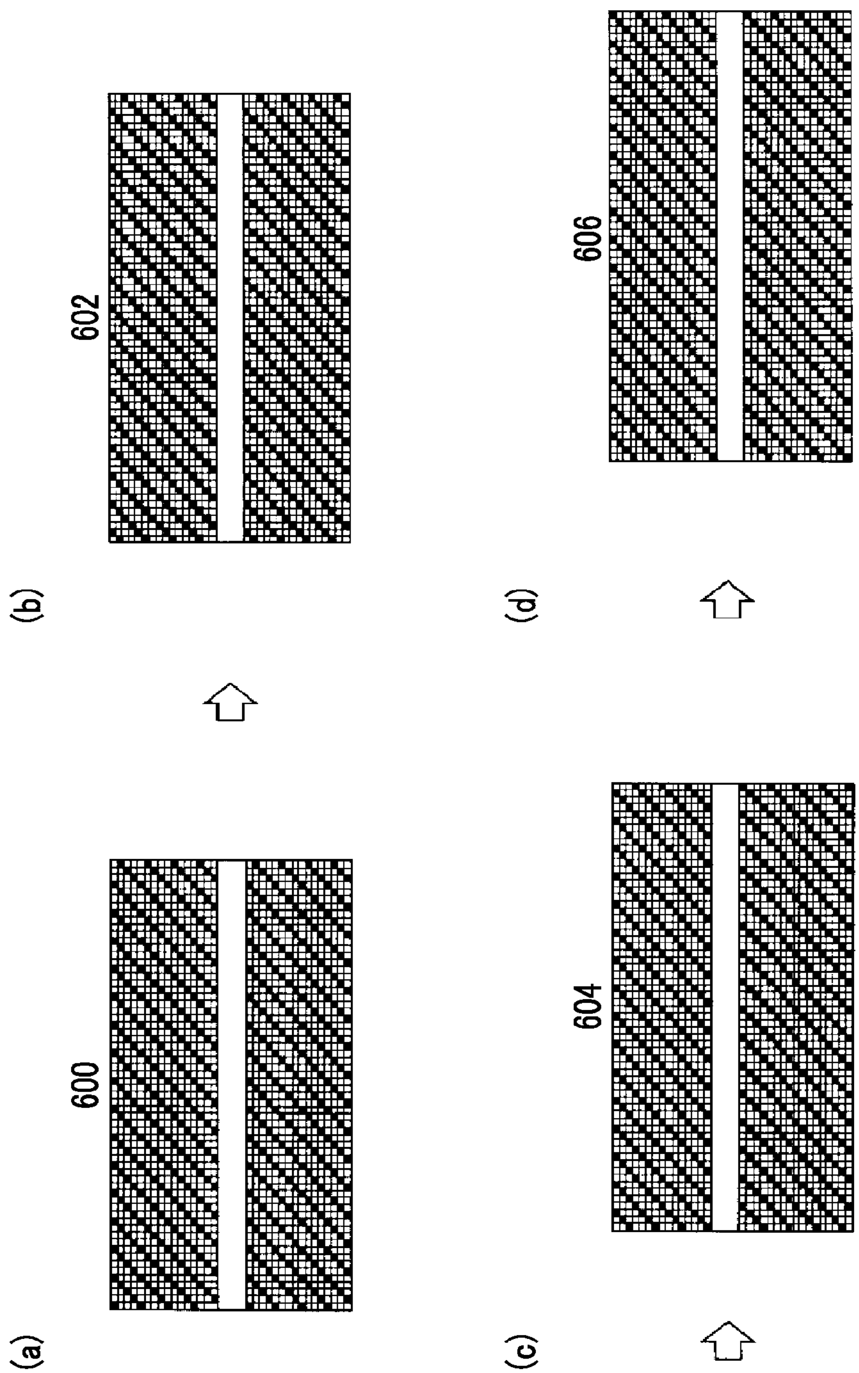
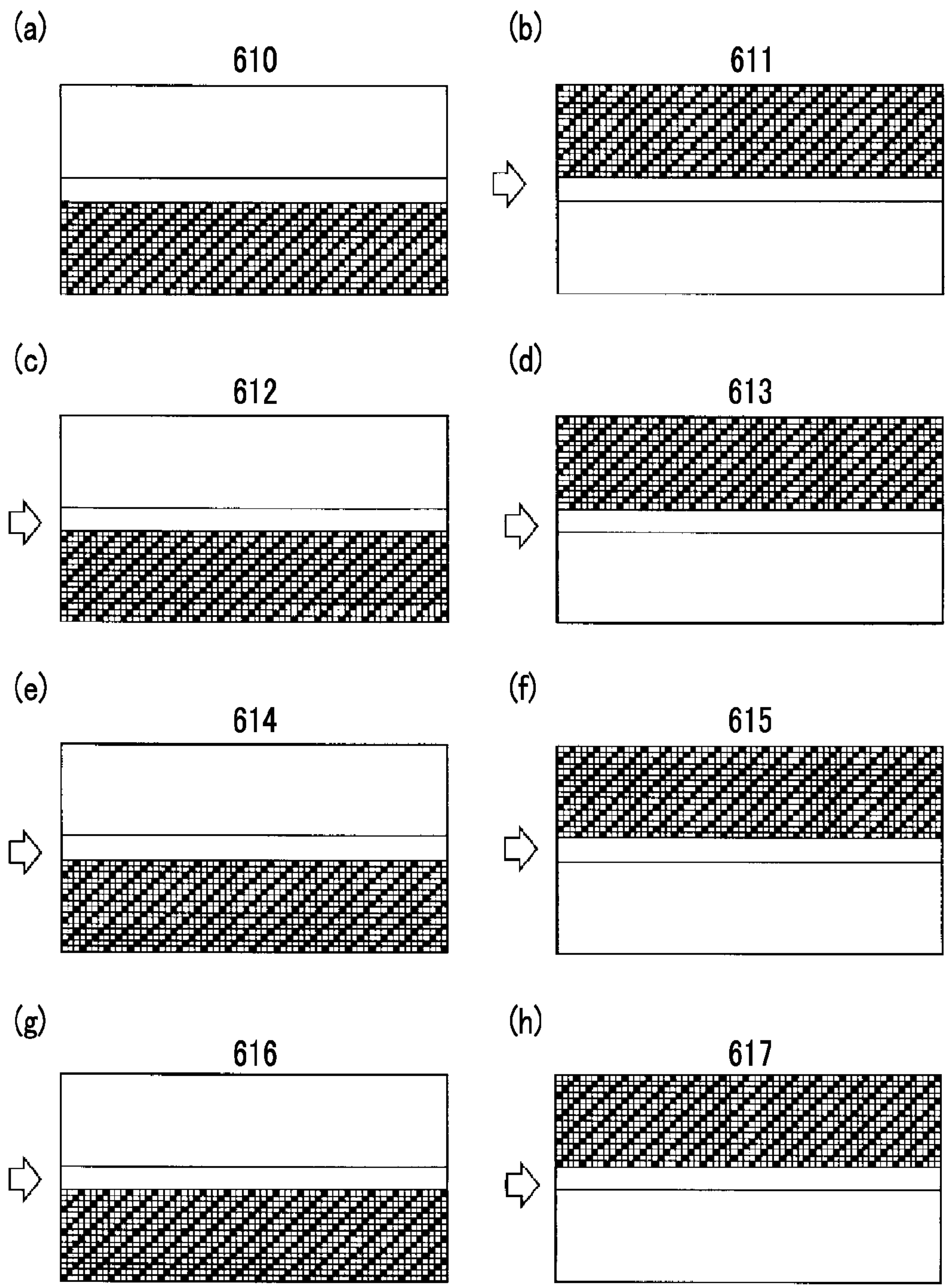


FIG. 34



LIQUID EJECTION DEVICE AND DUMMY JET METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of PCT International Application No. PCT/JP2014/058123 filed on Mar. 24, 2014, which claims priority under 35 U.S.C §119(a) to Japanese Patent Application No. 2013-073414 filed on Mar. 29, 2013, and Japanese Patent Application No. 2013-137026 filed on Jun. 28, 2013. Each of the above applications is hereby expressly incorporated by reference, in its entirety, into the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid ejection device and a dummy jet method, and more particularly, to a dummy jet for an ink jet head.

2. Description of the Related Art

In some types of ink jet head which use ink (for example, an aqueous pigment ink) using an aqueous solvent, a nozzle portion dries in the following situation and an ejection performance deteriorates.

When the nozzle portion is left unused in a standby cap portion, it is difficult to completely prevent the drying of the nozzle portion even though the standby cap portion has a moisture retention function of suppressing the drying of the nozzle portion.

When the nozzle portion is left unused above transportation means for transporting a recording medium, the nozzle portion dries while the recording medium is being moved from the transportation means to the standby cap portion even though the period for which the nozzle portion is left unused and the period for which the recording medium is moved are relatively short.

During image formation, a nozzle portion which does not eject ink or a nozzle portion which ejects a relatively small amount of ink dries.

As measures for the drying of ink in the nozzle portion, a dummy jet (preliminary ejection, idle ejection, or spitting) is performed as means for, before an ink ejection surface in which nozzle openings are formed is wiped (swept), removing ink whose viscosity has increased due to the drying of the nozzle opening and the vicinity of the nozzle opening and ink which has been attached to the edge of the nozzle opening and then semi-hardened.

For example, the dummy jet is performed for each nozzle about 20000 times to suppress a reduction in the ejection performance. However, mist is attached to the ink ejection surface by the dummy jet.

When a large amount of mist is attached to the ink ejection surface, ink which is ejected from the nozzle openings is combined with mist, which may cause a change in the ejection direction of the ejected ink, or the mist attached in the vicinity of the nozzle opening becomes hardened or semi-hardened, which may cause a change in the ejection direction of the ink ejected from the nozzle opening.

That is, the ejection of a large amount of ink in the dummy jet makes it possible to obtain the effect of suppressing the drying of ink in the nozzle portion, but causes another problem that mist is attached to the ink ejection surface.

When the number of ink ejections in the dummy jet increases, the amount of mist attached to the ink ejection surface increases. In order to remove mist attached to the ink

ejection surface, it is necessary to perform a separate process, such as a wiping process, which results in an increase in a maintenance period and maintenance costs. That is, a trade-off relationship is established between the suppression of the drying of ink in the nozzle portion by the dummy jet and the attachment of mist to the ink ejection surface by the dummy jet.

In an ink jet head which ejects black ink, a water repellent film on the ink ejection surface is worn by a carbon black pigment included in the black ink due to the attachment of mist to the ink ejection surface.

When the number of wiping operations which remove the mist attached to the ink ejection surface increases, the abrasion of the ink ejection surface is accelerated by the carbon black pigment, which makes it difficult to increase the durability of a liquid repellent film on the ink ejection surface. Then, the ink jet head (a head module forming the ink jet head) is frequently replaced, which results in a reduction in the operation efficiency of the device due to the replacement of the ink jet head and an increase in costs.

JP2009-45803A discloses a technique which relates to a time-division driving method for an ink jet head (recording head) and reduces the amount of mist attached to an ink ejection surface when a dummy jet (preliminary ejection) is performed.

JP2012-245758A discloses a technique which causes a phase difference between driving pulse signals applied to a plurality of actuators corresponding to a plurality of nozzles and changes the phase difference, depending on the length of a flow path, to reduce the amount of ink discharged in a dummy jet (purging).

JP3155762B discloses a technique which makes a driving frequency during a dummy jet (idle ejection) equal to a maximum driving frequency during ink ejection.

SUMMARY OF THE INVENTION

However, in the technique disclosed in JP2009-45803A, since the time-division driving is performed during the dummy jet, ink is ejected from adjacent nozzles in a short cycle. Therefore, the ejection is affected by crosstalk and is unstable. As a result, there is a concern that mist will be generated.

In JP2012-245758A, the ejection times of the nozzles deviate from each other in one ejection cycle. Therefore, there is a concern that mist will be generated due to crosstalk which is caused by the ejection of ink from adjacent nozzles in a short cycle.

JP3155762B does not disclose the same problem as that described in the invention, such as the generation of mist during the dummy jet, and merely discloses the ejection frequency in the dummy jet.

The invention has been made in view of the above-mentioned problems and an object of the invention is to provide a liquid ejection device and a dummy jet method which perform a dummy jet capable of suppressing the attachment of mist to a liquid ejection surface.

In order to achieve the object, according to the invention, there is provided a liquid ejection device including: an ink jet head in which a plurality of nozzle portions are arranged in a matrix in a row direction and a column direction which obliquely intersects the row direction; a plurality of pressurizing elements that are provided so as to correspond to the plurality of nozzle portions and generate an ejection force for ejecting a liquid from the corresponding nozzle portions; and a driving voltage supply unit that supplies a driving voltage to the plurality of pressurizing elements. The ink jet head is provided with supply flow paths for supplying the liquid to the plurality of nozzle portions. The plurality of nozzle portions which are supplied with the liquid from the same supply flow path are divided into two or more groups. The driving voltage supply unit supplies an ejection driving voltage for ejecting the liquid to each of the groups when a dummy jet is performed. During a period of time when the dummy jet is performed for one group, the driving voltage supply unit supplies a non-ejection driving voltage for preventing the liquid from being ejected to the other groups.

According to the invention, the plurality of nozzle portions which are supplied with the liquid from the same supply flow path are divided into two or more groups. For the period for which the dummy jet is performed for one group, the non-ejection driving voltage for preventing the liquid from being ejected is supplied to the other groups. Therefore, the nozzle portions which eject the liquid are distributed. A region in which a descending air current from the liquid ejection surface is generated is widened and a region in which an ascending air current to the liquid ejection surface is generated is narrowed. The probability of mist moving to the region in which the ascending air current is generated is reduced. As a result, the amount of mist moving to the liquid ejection surface is reduced and the attachment of mist to the liquid ejection surface is suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram schematically illustrating the structure of an ink jet recording device according to an embodiment of the invention.

FIG. **2** is a block diagram schematically illustrating the structure of a control system.

FIG. **3** is a plan view illustrating an ink jet head as viewed from an ink ejection surface.

FIG. **4** is a perspective view illustrating an example of the structure of a head module.

FIG. **5** is a diagram illustrating the arrangement of nozzles in the head module.

FIG. **6** is a cross-sectional view illustrating the internal structure of the head module.

FIG. **7** is a layout diagram schematically illustrating the relationship between an image recording position and a maintenance position.

FIG. **8** is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a first group in division driving ejection during a dummy jet.

FIG. **9** is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a second group in the division driving ejection during the dummy jet.

FIG. **10** is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a third group in the division driving ejection during the dummy jet.

FIG. **11** is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a fourth group in the division driving ejection during the dummy jet.

FIG. **12** is a diagram illustrating the application time of a driving voltage to each group during the dummy jet.

FIG. **13**A is a plan view schematically illustrating an aspect of the attachment of mist to the ink ejection surface when the division driving ejection is performed and FIG. **13**B is a plan view schematically illustrating an aspect of the attachment of mist to the ink ejection surface when collective driving ejection is performed.

FIG. **14** is a diagram schematically illustrating a descending air current region and an ascending air current region in a space between the ink ejection surface and an ink landing surface.

FIG. **15** is a table illustrating the attachment state of mist to the ink ejection surface due to a difference in ejection frequency in the dummy jet.

FIG. **16** is a graph illustrating the relationship between the ejection frequency and the speed of droplets in the dummy jet.

FIG. **17** is a table illustrating the attachment state of mist to the ink ejection surface due to a difference in throw distance in the dummy jet.

FIGS. **18**A to **18**D are diagrams illustrating another aspect of the division driving ejection during the dummy jet: FIG. **18**A is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a first group; FIG. **18**B is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a second group; FIG. **18**C is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a third group; and FIG. **18**D is a plan view schematically illustrating an ink ejection surface indicating nozzle portions belonging to a fourth group.

FIG. **19** is a diagram illustrating the effect of the division driving ejection during the dummy jet.

FIG. **20** is a flowchart illustrating the control flow of the dummy jet.

FIG. **21** is a diagram illustrating a technical problem of the dummy jet.

FIG. **22** is a diagram schematically illustrating a state between an ink ejection surface **277** and a liquid level **92**A during the dummy jet.

FIGS. **23**A and **23**B are diagrams illustrating another technical problem of the dummy jet: FIG. **23**A illustrates a state in which an ink jet head **56** is inclined at an angle γ_1 with respect to the horizontal plane; and FIG. **23**B illustrates a state in which the ink jet head **56** is inclined at an angle γ_2 ($<\gamma_1$) with respect to the horizontal plane.

FIG. **24** is a diagram illustrating another aspect of the division driving ejection during the dummy jet: (a) illustrates nozzle portions belonging to a second block of a first group; and (b) illustrates nozzle portions belonging to a first block of the first group.

FIG. **25** is a diagram illustrating another aspect of the division driving ejection during the dummy jet: (a) illustrates nozzle portions belonging to a second block of a second group; and (b) illustrates nozzle portions belonging to a first block of the second group.

FIG. **26** is a diagram illustrating another aspect of the division driving ejection during the dummy jet: (a) illustrates nozzle portions belonging to a second block of a third group; and (b) illustrates nozzle portions belonging to a first block of the third group.

FIG. **27** is a diagram illustrating another aspect of the division driving ejection during the dummy jet: (a) illustrates nozzle portions belonging to a second block of a fourth group; and (b) illustrates nozzle portions belonging to a first block of the fourth group.

FIGS. **28**A to **28**C are diagrams illustrating the effect of the dummy jet to which division driving ejection performed for each block is applied: FIG. **28**A illustrates the state of the ink ejection surface when the number of divisions is 8; FIG. **28**B illustrates the state of the ink ejection surface when there is no division; and FIG. **28**C illustrates the state of the ink ejection surface when the number of divisions is 4.

FIG. **29** is a diagram illustrating the attachment state of mist to an ink ejection surface **277** in each module.

FIGS. **30**A to **30**C are diagrams illustrating the effect of a dummy jet to which division driving ejection performed for each block is applied in another ink jet head: FIG. **30**A illustrates the state of an ink ejection surface when the number of divisions is 8; FIG. **30**B illustrates the state of the ink ejection surface when there is no division; and FIG. **30**C illustrates the state of the ink ejection surface when the number of divisions is 4.

FIG. **31** is a diagram illustrating the attachment state of mist to an ink ejection surface **277** in each module of another ink jet head.

FIG. **32** is a diagram illustrating the correlation between a factor for an increase in the amount of mist attached to the ink ejection surface **277** and a factor for a decrease in the amount of mist attached to the ink ejection surface **277**.

FIG. **33** is a diagram schematically illustrating masks applied to four-division driving ejection: (a) illustrates a mask corresponding to nozzle portions in a first group; (b) illustrates a mask corresponding to nozzle portions in a second group; (c) illustrates a mask corresponding to nozzle portions in a third group; and (d) illustrates a mask corresponding to nozzle portions in a fourth group.

FIG. **34** is a diagram schematically illustrating masks applied to eight-division driving ejection: (a) illustrates a mask corresponding to nozzle portions in a second block of a first group; (b) illustrates a mask corresponding to nozzle portions in a first block of the first group; (c) illustrates a mask corresponding to nozzle portions in a second block of a second group; (d) illustrates a mask corresponding to nozzle portions in a first block of the second group; (e) illustrates a mask corresponding to nozzle portions in a second block of a third group; (f) illustrates a mask corresponding to nozzle portions in a first block of the third group; (g) illustrates a mask corresponding to nozzle portions in a second block of a fourth group; and (h) illustrates a mask corresponding to nozzle portions in a first block of the fourth group.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, preferred embodiments of the invention will be described with reference to the accompanying drawings.

[Overall Structure of Ink Jet Recording Device]

FIG. **1** is a diagram illustrating the overall structure of an ink jet recording device (liquid ejection device) to which an ink jet head (liquid ejection head) according to an embodiment of the invention is applied.

An ink jet recording device **10** illustrated in FIG. **1** is an ink jet recording device which records an image on a sheet P in an ink jet manner using an aqueous ultraviolet (UV) ink (UV curable ink using an aqueous solvent).

The ink jet recording device **10** includes a sheet feed unit **12**, a process liquid applying unit **14**, a process liquid drying processing unit **16**, an image forming unit **18**, an ink drying processing unit **20**, a UV irradiation processing unit **22**, and a sheet discharge unit **24**. The sheet feed unit **12** feeds the sheet P. The process liquid applying unit **14** applies a process liquid to the surface of the sheet P fed from the sheet feed unit **12**. The process liquid drying processing unit **16** performs a process of drying the sheet P to which the process liquid has been applied by the process liquid applying unit **14**. The image forming unit **18** records an image on the sheet P dried by the process liquid drying processing unit **16** in the ink jet manner, using the aqueous UV ink. The ink drying processing unit **20** performs a process of drying the sheet P on which the image has been recorded by the image forming unit **18**. The UV irradiation processing unit **22** irradiates the sheet P dried by the ink drying processing unit **20** with UV rays (active rays) to fix the image. The sheet discharge unit **24** discharges the sheet P which has been irradiated with the UV light by the UV irradiation processing unit **22**.

<Sheet Feed Unit>

The sheet feed unit **12** includes a sheet feed tray **30**, a sucker device **32**, a sheet feed roller pair **34**, a feeder board **36**, a front lay **38**, and a sheet feed drum **40**. The sheet feed unit **12** feeds the sheets P stacked on the sheet feed tray **30** one by one to the process liquid applying unit **14**.

The sheets P stacked on the sheet feed tray **30** are sequentially drawn up one by one by the sucker device **32** (suction fit **32**A) and are fed to the sheet feed roller pair **34** (a pair of upper and lower rollers **34**A and **34**B).

The sheet P fed to the sheet feed roller pair **34** is transported forward by the pair of upper and lower rollers **34**A and **34**B and is then put on the feeder board **36**. The sheet P put on the feeder board **36** is transported by a tape feeder **36**A which is provided on a transportation surface of the feeder board **36**.

Then, during the transportation process, the sheet P is pressed against the transportation surface of the feeder board **36** by a retainer **36**B and a guide roller **36**C such that the unevenness of the sheet P is corrected. The leading end of the sheet P transported by the feeder board **36** comes into contact with the front lay **38** such that the inclination of the sheet P is corrected. Then, the sheet P is transported to the sheet feed drum **40**. Then, the leading end of the sheet P is held by a gripper **40**A of the sheet feed drum **40** and the sheet P is transported to the process liquid applying unit **14**.

<Process Liquid Applying Unit>

The process liquid applying unit **14** includes a process liquid applying drum **42** which transports the sheet P and a process liquid applying unit **44** that applies a predetermined process liquid to the surface of the sheet P transported by the process liquid applying drum **42**. The process liquid applying unit **14** applies (coats) the process liquid to the surface of the sheet P.

The process liquid applied to the surface of the sheet P has a function of aggregating a coloring material in the aqueous UV ink which is discharged to the sheet P by the image forming unit **18** in the later stage. The discharge of the aqueous UV ink to the sheet P having the process liquid applied to the surface thereof makes it possible to perform high-quality printing, without causing landing interference, even when a general-purpose print sheet is used.

The sheet P transported from the sheet feed drum **40** of the sheet feed unit **12** is transported to the process liquid applying drum **42**. The process liquid applying drum **42** is rotated, with the gripper **42**A holding (grasping) the leading end of the sheet P, such that the sheet P is wound around the process liquid applying drum **42** and transports the sheet P.

During the transportation process, a coating roller **44**A, to which a constant amount of process liquid measured by an anilox roller **44**C has been applied from a process liquid pan **44**B, comes into pressure contact with the surface of the sheet P and the process liquid is applied to the surface of the sheet P. A method of applying the process liquid is not limited to the roller application. For example, other methods, such as an ink jet method and an application method using a blade, can be used.

<Process Liquid Drying Processing Unit>

The process liquid drying processing unit **16** includes a process liquid drying processing drum **46** which transports the sheet P, a sheet transportation guide **48** which supports (guides) the rear surface of the sheet P, and a process liquid drying unit **50** which blows hot air to the surface of the sheet P transported by the process liquid drying processing drum **46** to dry the sheet P. The process liquid drying processing unit **16** performs a drying processing for the sheet P having the process liquid applied to the surface thereof.

The leading end of the sheet P, which has been transported from the process liquid applying drum **42** of the process liquid applying unit **14** to the process liquid drying processing drum **46**, is held by a gripper **46**A of the process liquid drying processing drum **46**.

The rear surface of the sheet P is supported by the sheet transportation guide **48**, with the front surface (the surface to which the process liquid has been applied) facing inward. In this state, the process liquid drying processing drum **46** is rotated to transport the sheet P.

When the sheet P is being transported by the process liquid drying processing drum **46**, hot air is blown from the process liquid drying unit **50** which is provided inside the process liquid drying processing drum **46** to the surface of the sheet P to dry the sheet P. Then, a solvent component in the process liquid is removed and an ink aggregation layer is formed on the surface of the sheet P.

<Image Forming Unit>

The image forming unit **18** includes an image forming drum **52**, a sheet pressing roller **54**, ink jet heads **56**C, **56**M, **56**Y, and **56**K, an in-line sensor **58**, a mist filter **60**, and a drum cooling unit **62**. The image forming drum **52** transports the sheet P. The sheet pressing roller **54** presses the sheet P transported by the image forming drum **52** to bring the sheet P into close contact with the circumferential surface of the image forming drum **52**. The ink jet heads **56**C, **56**M, **56**Y, and **56**K eject ink droplets of each color, that is, C, M, Y, and K to the sheet P. The in-line sensor **58** reads the image recorded on the sheet P. The mist filter **60** captures ink mist. The image forming unit **18** discharges ink droplets (aqueous UV ink droplets) of each color, that is, C, M, Y, and K to the surface of the sheet P having the process liquid layer formed thereon to form a color image on the surface of the sheet P.

The ink jet head applied to this example may be a line head in which nozzles are formed over a length corresponding to the overall width of the sheet P (the overall length of the sheet P in a main scanning direction perpendicular to the transportation direction of the sheet P) or a short serial head which has a size shorter than the overall width of the sheet P.

The leading end of the sheet P, which has been transported from the process liquid drying processing drum **46** of the process liquid drying processing unit **16** to the image forming drum **52**, is held by a gripper **52**A of the image forming drum **52**. In addition, the sheet P passes below the sheet pressing roller **54** and comes into close contact with the circumferential surface of the image forming drum **52**.

The sheet P which comes into close contact with the circumferential surface of the image forming drum **52** is sucked by a negative pressure generated by suction holes which are formed in the circumferential surface of the image forming drum **52** and is held on the circumferential surface of the image forming drum **52**.

When the sheet P which is transported while being sucked and held on the circumferential surface of the image forming drum **52** passes through ink discharge regions immediately below the ink jet heads **56**C, **56**M, **56**Y, and **56**K, the ink jet heads **56**C, **56**M, **56**Y, and **56**K discharge ink droplets of each color, that is, C, M, Y, and K to the surface of the sheet P to form a color image on the sheet P.

The ink discharged to the surface of the sheet P reacts with the ink aggregation layer formed on the surface of the sheet P and is fixed on the surface of the sheet P, without causing, for example, feathering and bleeding. Therefore, a high-quality image is formed on the surface of the sheet P.

When the sheet P having the image formed by the ink jet heads **56**C, **56**M, **56**Y, and **56**K passes through a reading region of the in-line sensor **58**, the image formed on the surface of the sheet P is read.

The image is read by the in-line sensor **58** if necessary. An image defect (image abnormality), such as an ejection failure or concentration unevenness, is detected from data read from the image. When the sheet P passes through the reading region of the in-line sensor **58**, the suction of the sheet P is released. Then, the sheet P passes below a guide **59** and is then transported to the ink drying processing unit **20**.

<Ink Drying Processing Unit>

The ink drying processing unit **20** includes an ink drying unit **68** that dries the sheet P transported by a chain gripper **64** and performs a drying process for the sheet P having the image formed thereon to remove a liquid component remaining on the surface of the sheet P.

An example of the structure of the ink drying unit **68** includes a heat source, such as a halogen heater or an infrared (IR) heater, and a fan which blows air (gas or fluid) heated by the heat source to the sheet P.

The leading end of the sheet P, which has been transported from the image forming drum **52** of the image forming unit **18** to the chain gripper **64**, is held by a gripper **64**D provided in the chain gripper **64**.

The chain gripper **64** has a structure in which a pair of endless chains **64**C are wound around a first sprocket **64**A and a second sprocket **64**B.

The rear surface of the rear end of the sheet P is sucked and held by a sheet holding surface of a guide plate **72** which is arranged at a predetermined distance from the chain gripper **64**.

<UV Irradiation Processing Unit>

The UV irradiation processing unit **22** includes a UV irradiation unit **74**. The UV irradiation processing unit **22** irradiates the image which is recorded using the aqueous UV ink with ultraviolet rays to fix the image on the surface of the sheet P.

An example of the structure of the UV irradiation unit includes an ultraviolet light source which generates UV light and an optical system which functions as means for focusing UV light and means for deflecting UV light.

When the sheet P transported by the chain gripper **64** reaches a UV light irradiation region of the UV irradiation unit **74**, the UV irradiation unit **74** provided in the chain gripper **64** performs a UV irradiation process for the sheet P.

That is, the sheet P which is transported by the chain gripper **64** while the leading end is held by the gripper and the rear surface of the rear end is sucked and held by the guide plate **72** is irradiated with UV light by the UV irradiation unit **74** that is provided at a position corresponding to the surface of the sheet P in a transportation path for the sheet P. A curing reaction occurs in the image (ink) irradiated with the UV light and the image is fixed to the surface of the sheet P.

The sheet P subjected to the UV irradiation process is transported to the sheet discharge unit **24** through an inclined transportation path **70**B. The UV irradiation processing unit

22 may include a cooling processing unit which performs a cooling process for the sheet P that passes through the inclined transportation path **70**B.

<Sheet Discharge Unit>

The sheet discharge unit **24** which collects the sheet P subjected to a series of image forming processes includes a sheet discharge tray **76** which collects a stack of the sheets P.

The chain gripper **64** (gripper **64**D) releases the sheet P on the sheet discharge tray **76** and stacks the sheet P on the sheet discharge tray **76**. The sheet discharge tray **76** collects a stack of the sheets P released from the chain gripper **64**. The sheet discharge tray **76** is provided with sheet guides (not illustrated) (for example, a front sheet guide, a rear sheet guide, and a side sheet guide) in order to arrange and stack the sheets P.

The sheet discharge tray **76** is provided so as to be moved up and down by a sheet discharge tray lifting device (not illustrated). The driving of the sheet discharge tray lifting device is controlled in operative association with an increase or decrease in the number of sheets P stacked on the sheet discharge tray **76** and the sheet discharge tray lifting device moves the sheet discharge tray **76** up and down such that the uppermost sheet P is located at a constant height.

The ink jet recording device **10** illustrated in FIG. **1** includes a maintenance unit (represented by reference numeral **90** in FIG. **7**) which performs a maintenance process for the ink jet heads **56**C, **56**M, **56**Y, and **56**K, which will be described in detail below.

Examples of the maintenance of the ink jet head include a dummy jet, wiping, pressure purging, and suction. In the dummy jet, a piezoelectric element (represented by reference numeral **230** in FIG. **6**) is operated to eject ink from each nozzle opening (represented by reference numerals **280**A and **280**B in FIG. **5**). An ink ejection surface (represented by reference numeral **227** in FIG. **3**, a liquid ejection surface) is swept by wiping. The internal pressure of the ink jet heads **56**C, **56**M, **56**Y, and **56**K is increased by pressure purging to discharge ink from all of the nozzle openings. Ink is drawn from the ink ejection surface into a nozzle portion by suction.

<Description of Control System>

FIG. **2** is a block diagram schematically illustrating the structure of a control system of the ink jet recording device **10** illustrated in FIG. **1**.

As illustrated in FIG. **2**, the ink jet recording device **10** includes, for example, a system controller **100**, a communication unit **102**, an image memory **104**, a transportation control unit **110**, a sheet feed control unit **112**, a process liquid application control unit **114**, a process liquid drying control unit **116**, an image forming control unit **118**, an ink drying control unit **120**, a UV irradiation control unit **122**, a sheet discharge control unit **124**, a maintenance control unit **126**, an operating unit **130**, and a display unit **132**.

The system controller **100** functions as control means for controlling the overall operation of each unit of the ink jet recording device **10** and also functions as arithmetic means for performing various types of arithmetic processing. The system controller **100** includes a central processing unit (CPU) **100**A, a read only memory (ROM) **100**B, and a random access memory (RAM) **100**C.

The system controller **100** also functions as a memory controller which controls the writing of data to memories, such as the ROM **100**B, the RAM **100**C, and the image memory **104**, and the reading of data from the memories.

FIG. **2** illustrates an aspect in which the memories, such as the ROM **100**B and the RAM **100**C, are provided in the system controller **100**. However, the memories, such as the ROM **100**B and the RAM **100**C, may be provided outside the system controller **100**.

The communication unit **102** includes a necessary communication interface and transmits and receives data to and from a host computer which is connected to the communication interface.

The image memory **104** functions as temporary storage means for storing various kinds of data including image data. The data is read from and written to the image memory **104** through the system controller **100**. The image data which is received from the host computer through the communication unit **102** is temporarily stored in the image memory **104**.

The transportation control unit **110** controls the operation of a transportation system for the sheet P in the ink jet recording device **10** (the transportation of the sheet P from the sheet feed unit **12** to the sheet discharge unit **24**). The transportation system includes the sheet feed drum **40** in the sheet feed unit **12** illustrated in FIG. **1**, the process liquid applying drum **42** in the process liquid applying unit **14**, the process liquid drying processing drum **46** in the process liquid drying processing unit **16**, the image forming drum **52** in the image forming unit **18**, and the chain gripper **64** which is common to the ink drying processing unit **20**, the UV irradiation processing unit **22**, and the sheet discharge unit **24**.

The sheet feed control unit **112** controls the operation of each unit of the sheet feed unit **12**, such as the driving of the sheet feed roller pair **34** and the driving of the tape feeder **36**A, in response to commands from the system controller **100**.

The process liquid application control unit **114** controls the operation of each unit of the process liquid applying unit **14** (for example, the amount of process liquid applied and the application time of the process liquid), such as the operation of the process liquid applying unit **44**, in response to commands from the system controller **100**.

The process liquid drying control unit **116** controls the operation of each unit of the process liquid drying processing unit **16** in response to commands from the system controller **100**. That is, the process liquid drying control unit **116** controls the operation of the process liquid drying unit **50** (see FIG. **1**), such as drying temperature, the flow rate of dry air, and the blowing time of dry air.

The image forming control unit **118** controls the discharge (ejection) of ink from the image forming unit **18** (the ink jet heads **56**C, **56**M, **56**Y, and **56**K) in response to commands from the system controller **100**.

That is, the image forming control unit **118** illustrated in FIG. **2** includes an image processing unit, a driving waveform generation unit, a driving waveform storage unit, and a driving circuit (a head driver and a driving voltage supply unit). The image processing unit forms dot data from input image data. The driving waveform generation unit generates the waveform of a driving voltage. The driving waveform storage unit stores the waveform of the driving voltage. The driving circuit supplies a driving voltage with a driving waveform corresponding to the dot data to each of the ink jet heads **56**C, **56**M, **56**Y, and **56**K.

Examples of the driving voltage include an ejection driving voltage for ejecting ink and a non-ejection driving voltage for preventing ink from being ejected. Examples of the non-ejection driving voltage include a meniscus micro-vibration voltage for finely vibrating a meniscus to such an extent that ink is not ejected and a driving voltage which prevents a piezoelectric element **230** from operating.

The meniscus micro-vibration voltage may have a smaller amplitude than the ejection driving voltage (for example, an amplitude that is half the amplitude of the ejection driving voltage) and a high-frequency pulse voltage (for example, a frequency that is ten times higher than that of the ejection driving voltage) may be applied as the meniscus micro-vibration voltage. In addition, the meniscus micro-vibration voltage may be a combination of these voltages.

The supply of the driving voltage which does not operate the piezoelectric element is synonymous with the non-supply of a driving voltage. In the following description, the "driving voltage" simply means the ejection driving voltage.

The image processing unit performs a color separation (division) process of separating input image data (raster data represented by a digital value of 0 to 255) into R, and B, a color conversion process of converting R, and B into C, M, Y, and K, a correction process, such as a gamma correction process or an unevenness correction process, and a halftone process of converting data of each color having an M value into data of each color having an N value (M>N; M is an integer equal to or greater than 3 and N is an integer of equal to or greater than 2).

The discharge time of ink to each pixel position and the amount of ink discharged are determined on the basis of dot data generated by the process of the image processing unit. A driving voltage corresponding to the discharge time of ink to each pixel position and the amount of ink discharged is generated. The driving voltage is supplied to the ink jet heads **56**C, **56**M, **56**Y, and **56**K. Dots are formed at each pixel position by ink droplets discharged from the ink jet heads **56**C, **56**M, **56**Y, and **56**K.

The ink drying control unit **120** controls the operation of the ink drying processing unit **20** in response to commands from the system controller **100**. That is, the ink drying control unit **120** controls the operation of the ink drying unit **68** (see FIG. **1**), such as drying temperature, the flow rate of dry air, and the blowing time of dry air.

The UV irradiation control unit **122** controls the amount of UV light irradiated by the UV irradiation processing unit **22** (the intensity (amount of irradiation) of UV light) in response to commands from the system controller **100** and also controls the irradiation time of the UV light.

The sheet discharge control unit **124** controls the operation of the sheet discharge unit **24** such that the sheet P is stacked on the sheet discharge tray **76**, in response to commands from the system controller **100**.

The maintenance control unit **126** controls the maintenance unit **90** which maintains the ink jet heads **56**C, **56**M, **56**Y, and **56**K (see FIG. **1**) in response to commands from the system controller **100**.

The maintenance control unit **126** controls the operation of a moving mechanism which moves the ink jet heads **56**C, **56**M, **56**Y, and **56**K from an image recording position to a maintenance position and controls the operation of a moving mechanism of a standby cap portion (which is not illustrated in FIG. **2** and is represented by reference numeral **92** in FIG. **7**).

In addition, the maintenance control unit **126** controls an internal pressure adjustment unit (not illustrated) which adjusts the internal pressure of the ink jet heads **56**C, **56**M, **56**Y, and **56**K and a driving circuit which applies the driving voltage to the ink jet heads **56**C, **56**M, **56**Y, and **56**K during a dummy jet through the system controller **100**.

The operating unit **130** includes operating members, such as operation buttons, a keyboard, and a touch panel, and transmits operation information which is input from operating means to the system controller **100**. The system controller **100** performs various processes according to the operation information transmitted from the operating unit **130**.

The display unit **132** includes a display device, such as an LCD panel, and displays information, such as various kinds of setting information of the device and abnormality information, on the display device in response to commands from the system controller **100**.

[Structure of Ink Jet Head]

Next, the structure of the ink jet head according to the embodiment of the invention will be described in detail.

<Overall Structure>

FIG. **3** is a diagram illustrating the structure of the ink jet heads **56**C, **56**M, **56**Y, and **56**K illustrated in FIG. **1**. The same structure is applied to the ink jet heads **56**C, **56**M, **56**Y, and **56**K which respectively correspond to C, M, Y, and K. Therefore, when the ink jet heads **56**C, **56**M, **56**Y, and **56**K do not need to be distinguished from each other, the alphabetical characters of the ink jet heads **56**C, **56**M, **56**Y, and **56**K may be omitted.

The ink jet head **56** illustrated in FIG. **3** has a structure in which a plurality of head modules **200** are connected in the width direction of the sheet P (X direction) perpendicular to the relative transportation direction of the sheet P (Y direction).

A suffix number (an integer after "-" (hyphen)) appended to the head module **200** indicates that the head module is an i-th (an integer from 1 to n) head module.

A plurality of nozzle openings (which are not illustrated in FIG. **3** and are represented by reference numerals **280**A and **280**B in FIG. **5**) are provided in an ink ejection surface **277** of each head module **200**.

That is, the ink jet head **56** illustrated in FIG. **3** is a full-line ink jet head (single-pass and page-wide head) in which a plurality of nozzle openings are arranged over a length corresponding to the overall width L_{max} of the sheet P.

Here, the "overall width L_{max} of the sheet P" is the overall length of the sheet P in the X direction perpendicular to the relative transportation direction (Y direction) of the sheet P. The term "perpendicular" includes an aspect in which the same operation and effect as those when the intersection angle is substantially 90° are obtained among aspects in which the intersection angle is less than or greater than 90°.

<Example of Structure of Head Module>

FIG. **4** is a perspective view (including a partial cross-sectional view) illustrating the head module **200**. FIG. **5** is a perspective plan view illustrating the ink ejection surface **277** of the head module **200** illustrated in FIG. **4**.

As illustrated in FIG. **4**, the head module **200** includes an ink supply unit including an ink supply chamber **232** and an ink circulation chamber **236** which are provided on the side (the upper side in FIG. **4**) opposite to the ink ejection surface **277** of the nozzle plate **275**.

The ink supply chamber **232** is connected to an ink tank (not illustrated) through a supply pipe line **252**. The ink circulation chamber **236** is connected to a collection tank (not illustrated) through a circulation pipe line **256**.

The number of nozzles is not illustrated in FIG. **5**. However, a plurality of nozzle openings **280**A and **280**B are formed in a two-dimensional nozzle array on the ink ejection surface **277** of the nozzle plate **275** in one head module **200**.

That is, the head module **200** has, in a plan view, a parallelogram shape which has a long-side end surface along a V direction which has an inclination of an angle β with respect to the X direction and a short-side end surface along a W direction which has an inclination of an angle α with respect to the Y direction. The plurality of nozzle openings **280**A and **280**B are arranged in a row direction along the V direction and a column direction along the W direction.

The head module **200** can be divided into two blocks **203**A and **203**B including independent nozzle openings **280**A and **280**B and independent flow paths connected to the nozzle openings **280**A and **280**B in the W direction.

In the first block **203**A, a supply flow path **214**A is provided for each nozzle column of a plurality of nozzle openings **280**A (nozzle portions **281**A) which are arranged in the W direction. The plurality of supply flow paths **214**A are connected to a main flow path and **215**A which is provided in the V direction.

Similarly, in the second block **203**B, a supply flow path **214**B is provided for each nozzle column of a plurality of nozzle openings **280**B (nozzle portions **281**B) which are arranged in the W direction along the nozzle column. The plurality of supply flow paths **214**B are connected to a main flow path **215**B which is provided in the V direction.

Ink is supplied from the same supply flow path **214**A to the nozzle portions **281**A belonging to the same nozzle row. Ink is supplied from the same supply flow path **214**B to the nozzle portions **281**B belonging to the same nozzle row.

In the aspect illustrated in FIG. **5**, the number of nozzle portions **281**A in the first block **203**A is equal to the number of nozzle portions **281**B in the second block **203**B. The nozzle portions **281**A and the nozzle portions **281**B have the same arrangement.

The arrangement of the nozzle openings **280**A and **280**B is not limited to the aspect illustrated in FIG. **5**. For example, the plurality of nozzle openings **280**A and **280**B may be arranged in the row direction along the X direction and the column direction which obliquely intersects the X direction.

FIG. **6** is a cross-sectional view illustrating the internal structure of the head module **200**. Reference numeral **214** indicates an ink supply path. Reference numeral **218** indicates a pressure chamber (liquid chamber). Reference numeral **216** indicates an individual supply path which connects each pressure chamber **218** and the supply flow path **214**. Reference numeral **220** indicates a nozzle connection path which connects the pressure chamber **218** and the nozzle opening **280**. Reference numeral **226** indicates an individual circulation flow path which connects the nozzle connection path **220** and a common circulation flow path **228**.

A diaphragm **266** is provided on a flow path structure **210** forming these flow path portions (**214**, **216**, **218**, **220**, **226**, and **228**). A piezoelectric element **230** (pressurizing element) which has a laminated structure of a lower electrode (common electrode) **265**, a piezoelectric layer **231**, and an upper electrode (individual electrode) **264** is provided above the diaphragm **266**, with an adhesive layer **267** interposed therebetween.

The upper electrode **264** is an individual electrode which is patterned so as to correspond to the shape of each pressure chamber **218**. The piezoelectric element **230** is provided for each pressure chamber **218**.

The supply flow path **214** is connected to the ink supply chamber **232** described with reference to FIG. **4**. Ink is supplied from the ink supply path to the pressure chamber **218** through the individual supply path **216**. When a driving voltage is applied to the upper electrode **264** of the piezoelectric element **230** provided in the corresponding pressure chamber **218** on the basis of an image signal of the image to be formed, the piezoelectric element **230** and the diaphragm **266** are deformed to change the volume of the pressure chamber **218**. Then, ink is ejected from the nozzle opening **280** through the nozzle connection path **220** due to a change in pressure.

The driving of the piezoelectric element **230** corresponding to each nozzle opening **280** is controlled on the basis of dot arrangement data which is generated from image information to eject ink droplets from the nozzle openings **280**. While the sheet P (see FIG. **3**) is transported in the Y direction at a constant speed, the ejection time of ink from each nozzle opening **280** is controlled according to the transportation speed, which makes it possible to record a desired image on the sheet.

Although not illustrated in the drawings, the pressure chamber **218** which is provided so as to correspond to each nozzle opening **280** has a substantially square shape in a plan view. An outlet to the nozzle opening **280** is provided at one of two corners on a diagonal line and an inlet (supply port) **216** for supplying ink is provided at the other corner.

The shape of the pressure chamber is not limited to a square. Alternatively, the pressure chamber may have various planar shapes, such as a quadrangle (for example, a rhombus or a rectangle), a pentagon, a hexagon, other polygons, a circle, and an ellipse.

The common circulation flow path **228** is connected to the ink circulation chamber **236** described with reference to FIG. **5**. Ink is constantly collected to the common circulation flow path **228** through the individual circulation flow path **226**, which prevents ink in the nozzle portion from thickening during a non-ejection (non-driving) operation.

In this example, the ink jet head ejects ink using the piezoelectric element. However, the ink jet head may be a thermal type which generates a film boiling phenomenon using a heating element provided in the liquid chamber to eject ink.

[Description of Maintenance of Ink Jet Head]

FIG. **7** is a layout diagram schematically illustrating the relationship between the image recording position and the maintenance position. In FIG. **7**, only one of the ink jet heads **56**C, **56**M, **56**Y, and **56**K which are arranged in the depth direction of the plane of paper is represented by reference numeral **56** and is illustrated, and the other ink jet heads are not illustrated.

The maintenance unit **90** illustrated in FIG. **7** includes the standby cap portion **92**, an ink receiver **94**, a waste tank **96**, and a wiping processing unit **97**. Reference numeral **92**A indicates the liquid level (the surface on which ink is landed during a dummy jet) of the standby cap portion **92**.

The ink jet head **56** represented by a solid line in FIG. **7** is arranged at the image recording position. The image recording position is a position where ink is ejected in order to form an image on the sheet P transported by the image forming drum **52** (see FIG. **1**).

The distance (throw distance) between the sheet P and the ink ejection surface **277** of the ink jet head **56** at the image recording position is in the range of 1 to 2 millimeters.

In order to move the ink jet head **56** from the image recording position to the maintenance position, a head mechanism (not illustrated) is operated to move the ink jet head **56** upward in the vertical direction and then move the ink jet head **56** in the horizontal direction (a direction parallel to the longitudinal direction of the ink jet head **56**).

In FIG. **7**, the ink jet head **56** arranged at the maintenance position is represented by a dashed line. When the ink jet head **56** is moved to the maintenance position, a standby cap portion moving mechanism (not illustrated) is used to move the standby cap portion **92** such that the standby cap portion **92** is mounted on the ink ejection surface **277** of the ink jet head **56**.

Maintenance processes, such as a dummy jet, pressure purging, and suction, are performed for the ink jet head **56**, with the standby cap portion **92** mounted on the ink ejection surface **277**. When these processes end, the standby cap portion **92** is separated from the ink ejection surface **277** of the ink jet head **56** and the ink jet head **56** is moved to the image recording position.

The wiping processing unit **97** is provided between the image recording position and the maintenance position of the ink jet head **56**. In the wiping processing unit **97**, a web **98** which is wetted with a cleaning liquid comes into contact with the ink ejection surface **277**. In this state, the ink jet head **56** is moved and the ink ejection surface **277** is swept by the web **98**.

FIG. **7** illustrates the maintenance unit **90** corresponding to one head. However, the structure illustrated in FIG. **7** may be provided so as to correspond to each of the ink jet heads **56**C, **56**M, **56**Y, and **56**K. Alternatively, one maintenance unit **90** may be used to perform the maintenance process for all of the ink jet heads **56**C, **56**M, **56**Y, and **56**K.

The standby cap portion **92** illustrated in FIG. **7** is inclined with respect to the horizontal plane so as to correspond to the inclination of the ink jet head **56** with respect to the horizontal plane, which is not illustrated in detail in FIG. **7**. The standby cap portion **92** illustrated in FIG. **7** is inclined in a direction from the front surface to the rear surface of FIG. **7** or a direction from the rear surface to the front surface of FIG. **7** (see FIGS. **23**A and **23**B).

[Detailed Description of Dummy Jet]

<Description of Division Driving Ejection>

Next, the dummy jet of the ink jet head **56** will be described. The dummy jet which will be described below has a structure in which one head module **200** forming the ink jet head **56** is divided into four groups and the dummy jet is sequentially performed for each group.

FIGS. **8** to **11** are diagrams illustrating division driving ejection in the dummy jet and are plan views schematically illustrating an ink ejection surface indicating the nozzle portions **281** (nozzle openings **280**) which belong to the first to fourth groups in the dummy jet.

In FIGS. **8** to **11**, one square-shaped mass indicates the nozzle portion **281** (nozzle opening **280**), a black mass indicates the nozzle portion **281** belonging to each group, and a white mass indicates the nozzle portion **281** belonging to the other groups.

In FIGS. **8** to **11**, only one head module **200** forming the ink jet head **56** is illustrated and a white portion (a non-forming portion in which the nozzle opening **280** is not formed) at the center in the W direction (Y direction in FIG. **5**) is a gap portion **203**C which is the boundary between the blocks forming one head module **200**. In FIG. **5**, the gap portion **203**C is represented by a one-dot chain line and does not have a reference numeral. In FIGS. **8** to **11**, it is assumed that the upper block is a first block **203**A and the lower block is a second block **203**B.

In FIGS. **8** to **11**, the vertical direction (up-down direction) is the W direction (the direction of the nozzle column) in FIG. **5**, the horizontal direction (left-right direction) is the V direction in FIG. **5**, and the inclined lattice in the arrangement of the nozzle portions **281** in FIG. **5** is replaced with a square lattice.

Nozzle portions **281-1** belonging to the first group illustrated in FIG. **8** are arranged at an interval of four nozzles in the V direction and the W direction. Similarly, nozzle portions **281-2** belonging to the second group illustrated in FIG. **9** are arranged at an interval of four nozzles in the V direction and the W direction. Nozzle portions **281-3** belonging to the third group illustrated in FIG. **10** are arranged at an interval of four nozzles in the V direction and the W direction. Nozzle portions **281-4** belonging to the fourth group illustrated in FIG. **11** are arranged at an interval of four nozzles in the V direction and the W direction.

The nozzle portion **281-1** belonging to the first group and the nozzle portion **281-2** belonging to the second group are adjacent to each other in the V direction and the W direction. Similarly, the nozzle portion **281-2** belonging to the second group and the nozzle portion **281-3** belonging to the third group are adjacent to each other in the V direction and the W direction. The nozzle portion **281-3** belonging to the third group and the nozzle portion **281-4** belonging to the fourth group are adjacent to each other in the V direction and the W direction. The nozzle portion **281-4** belonging to the fourth group and the nozzle portion **281-1** belonging to the first group are adjacent to each other in the V direction and the W direction.

That is, the head module **200** is configured such that adjacent nozzle portions **281** belong to different groups in the V direction and the W direction and the nozzle portions belonging to the same group are arranged in a direction which is inclined with respect to the V direction and the W direction.

In other words, among the nozzle portions **281** which belong to the same group, the distance between nozzle portions **281** which are connected to the same supply flow path **214**A or **214**B (see FIG. **5**) (the nozzle portions **281** in the same nozzle column) is equal to or greater than a value corresponding to two nozzles.

(a) to (d) of FIG. **12** are diagrams illustrating driving voltages **300**, **302**, **304**, and **306** which are applied to each group and the supply time of the driving voltage in the dummy jet.

As illustrated in (a) to (d) of FIG. **12**, the driving voltage applied to one group is a pulse voltage corresponding to the number of ejections which has an ejection period T and a non-supply period (time difference) t_d is provided between the driving voltage applied to one group and the driving voltage applied to another group.

That is, the dummy jet according to this example is performed for each group. When the dummy jet for one group ends, the dummy jet is performed for the next group after a predetermined driving voltage non-supply period t_d has elapsed (time interval driving).

In other words, for the period for which the dummy jet is performed for a given group, the dummy jet is not performed for the other groups. That is, the non-ejection driving voltage is supplied to the piezoelectric elements **230** (see FIG. **6**) corresponding to the nozzle portions **281** belonging to the other groups. For the groups for which the dummy jet is performed, ink is ejected from the nozzle portions **281** belonging to the same group (see FIGS. **8** to **11**) at the same time. That is, the ejection driving voltage is supplied to the piezoelectric elements **230** corresponding to the nozzle portions **281** belonging to the group for which the dummy jet is performed.

The non-ejection driving voltage is generated in the driving circuit illustrated in FIG. **2** and is supplied to the piezoelectric element **230** (see FIG. **6**), similarly to the ejection driving voltage.

In the group for which the dummy jet is not performed, when the non-ejection driving voltage is supplied, the meniscus in the nozzle portion **281** is finely vibrated to prevent the drying of ink in the vicinity of the nozzle opening **280**.

(a) of FIG. **12** illustrates the driving voltage (ejection driving voltage) **300** which is supplied to the piezoelectric element **230** (see FIG. **6**) corresponding to the nozzle portion **281-1** (see FIG. **8**) belonging to the first group. The driving voltage **300** illustrated in (a) of FIG. **12** includes a pulse voltage corresponding to the number of ejections in one dummy jet and the frequency of the driving voltage is the highest ejection frequency used to form an image.

Similarly, (b) of FIG. **12** illustrates the driving voltage **302** which is supplied to the piezoelectric element **230** corresponding to the nozzle portion **281-2** (see FIG. **9**) belonging to the second group. (c) of FIG. **12** illustrates the driving voltage **304** which is supplied to the piezoelectric element **230** corresponding to the nozzle portion **281-3** (see FIG. **10**) belonging to the third group. (d) of FIG. **12** illustrates the driving voltage **306** which is supplied to the piezoelectric element **230** corresponding to the nozzle portion **281-4** (see FIG. **11**) belonging to the fourth group.

The period T_I between the start edge of the driving voltage **300** (the rising edge of an initial pulse voltage) and the start edge of the driving voltage **302** (the rising edge of an initial pulse voltage) is longer than a period obtained by multiplying the period T which is calculated as the reciprocal of an ejection frequency applied to the dummy jet by the number of ejections in the dummy jet.

Similarly, the period between the start edge of the driving voltage **302** and the start edge of the driving voltage **304** and the period between the start edge of the driving voltage **304** and the start edge of the driving voltage **306** are longer than a period obtained by multiplying a period T longer than the period T which is calculated as the reciprocal of the ejection frequency applied to the dummy jet by the number of ejections in the dummy jet.

Similarly to the driving voltage **300**, each of the driving voltages **302**, **304**, and **306** includes a pulse voltage corresponding to the number of ejections in one dummy jet and the frequency thereof is the highest ejection frequency used to form an image.

A period difference t_d between the supply start times of the driving voltages **300**, **302**, **304**, and **306** in the groups can be appropriately determined.

FIGS. **13**A and **13**B are plan views of the ink ejection surface **277** which schematically illustrate aspects in which mist is attached to the ink ejection surface **277**. FIG. **13**A illustrates the aspect in which mist is attached to the ink ejection surface **277** when the division driving ejection is performed and FIG. **13**B illustrates the aspect in which mist is attached to the ink ejection surface **277** when collective driving ejection is performed.

The conditions of the dummy jet are as follows:

The number of nozzles per head module: 2048 nozzles;

The number of divisions: 4 (512 nozzles);

The number of dummy jets (the number of ejections): 20000;

The ejection frequency: 25 kHz;

The amount of ink ejected in one ejection operation: 9 picoliters; and

The distance between the ink ejection surface and the liquid level (which is represented by reference numeral **92**A in FIG. **14**): 3.4 millimeters.

The dummy jet was performed for all of the head modules forming the ink jet head under these conditions and the ink ejection surface **277** of each head module was visibly inspected to check the attachment state of mist. As a comparative example, the division driving ejection was not performed, the collective driving ejection was performed, ink was ejected from all of the nozzle portions **281**A and **281**B of all of the head modules at the same time to perform a dummy jet and the ink ejection surface **277** of each head module was visibly inspected to check the attachment state of mist.

FIGS. **13**A and **13**B illustrate the results for an arbitrary head module. When the division driving ejection illustrated in FIG. **13**A is performed, little mist is attached to the ink ejection surface **277**. On the other hand, when the collective driving ejection illustrated in FIG. **13**B is performed, a large amount of mist **320** is attached to the ink ejection surface **277**.

That is, when the division driving ejection is applied to the dummy jet, it is possible to significantly reduce the amount of mist attached to the ink ejection surface **277**, as compared to the collective driving ejection according to the related art.

Here, the collective driving ejection means ink ejection which has been performed in the dummy jet in the related art. In the collective driving ejection, ink is ejected from all of the nozzle openings **280**A and **280**B of one head module **200** at the same time.

The reasons why the amount of mist attached to the ink ejection surface **277** is reduced by the division driving ejection are as follows.

(Reason 1)

The nozzle portions **281** which eject ink at the same time are arranged at an interval of three nozzles in the V direction and the W direction and the crosstalk between the nozzle portions **281** which eject ink at the same time is reduced.

Ink is ejected at the same time from the nozzle portions **281** which are supplied with ink from the same supply flow paths **214**A and **214**B, but the crosstalk between the nozzle portions **281** is reduced since the nozzle portions **281** are separated by a distance corresponding to three nozzles.

When the crosstalk is reduced, the ejection of ink from each nozzle portion **281** is stabilized and the amount of mist generated is reduced. As a result, the amount of mist attached to the ink ejection surface **277** is reduced.

(Reason 2)

FIG. **14** is a diagram schematically illustrating a descending air current region **336** and an ascending air current region **338** in a space between the ink ejection surface **277** and the liquid level **92**A. When ink **330** is ejected from the nozzle opening **280**, a descending air current (represented by a white down arrow) from the nozzle opening **280** to the liquid level **92**A is generated around the nozzle opening **280** and the descending air current region **336** is formed.

In contrast, an ascending air current (represented by a white up arrow) is generated around the descending air current region **336** (a region between the nozzle openings **280**) and the ascending air current region **338** is formed. When floating mist **332**B which floats in a space between the ink ejection surface **277** and an ink landing surface enters the ascending air current region **338**, the floating mist **332**B moves to the ink ejection surface **277** and is attached to the ink ejection surface **277**.

Floating mist **332**A in the descending air current region **336** moves to the liquid level **92**A and lands on the liquid level **92**A.

In the case in which the division driving ejection is applied to the dummy jet, even when the floating mist **332**A which floats in the space between the ink ejection surface **277** and the ink landing surface is generated, the floating mist is less likely to enter the ascending air current region

338 since the descending air current region **336** is wide due to a large gap between the nozzle openings **280** from which ink is ejected. As a result, the amount of mist which reaches the ink ejection surface **277** is reduced.

In this example, one head module **200** is divided into four groups. However, the number of groups may be equal to or greater than 2, considering the reason why the attachment of mist to the ink ejection surface **277** is suppressed. That is, the nozzle portions **281** belonging to the same group may be separated by a distance corresponding to two nozzles or more among the nozzle portions **281** which are supplied with ink from the same supply flow paths **214**A and **214**B.

When the number of groups increases, it is possible to improve the effect of suppressing the attachment of mist to the ink ejection surface **277**. However, when the number of groups is too large, the whole processing time increases. Therefore, the number of groups may be determined, considering the whole processing period.

<For Ejection Frequency>

FIG. **15** is a table illustrating the attachment state of mist to the ink ejection surface according to a difference in ejection frequency during the dummy jet.

Here, a difference in the attachment of mist to the ink ejection surface **277** due to the difference in ejection frequency after the division driving ejection is applied will be described.

In the above-mentioned dummy jet conditions, the ejection frequency was set to 1 kilohertz (kHz), 2 kHz, 5 kHz, 10 kHz, 17 kHz, 25 kHz, and 29 kHz and the ink ejection surface **277** was visibly inspected to check the attachment state of mist.

In the evaluation of the amount of mist attached illustrated in FIG. **15**, "good" indicates that no mist was attached to the ink ejection surface **277** (see FIG. **13**) or little mist was attached to the ink ejection surface **277** (the amount of mist attached was in an allowable range) (see FIG. **13**A). In contrast, in the evaluation of the amount of mist attached, "poor" indicates that a large amount of mist was attached to the ink ejection surface **277** (the amount of mist attached was beyond the allowable range) (see FIG. **13**B).

As illustrated in FIG. **15**, when the ejection frequency is 1 kHz, 2 kHz, and 5 kHz, the evaluation result of the amount of mist attached is "poor". When the ejection frequency is 10 kHz, 17 kHz, 25 kHz, and 29 kHz, the evaluation result of the amount of mist attached is "good".

That is, when the ejection frequency is equal to or higher than 10 kHz, it is possible to suppress the attachment of mist to the ink ejection surface **277**. When the ejection frequency is relatively high, it is possible to improve the effect of suppressing the attachment of mist.

FIG. **16** is a graph illustrating the relationship between the ejection frequency and the speed of droplets in the dummy jet. In FIG. **16**, the horizontal axis indicates the ejection frequency (kilohertz (kHz)) and the vertical axis indicates the ejection speed of ink droplets (meters per second (m/s)).

Data (represented by a black rectangle) denoted by reference numeral **360** is data when ink is ejected from only one nozzle opening **280** and data (represented by a black circle) denoted by reference numeral **362** is data when ink is ejected from all of the nozzle openings **280**.

The speed of droplets when ink is ejected from only one nozzle opening **280**, which is denoted by reference numeral **360**, is constant at an ejection frequency of up to 25 kHz and is slightly reduced when the ejection frequency is greater than 25 kHz. In contrast, the ejection speed when ink is ejected from all of the nozzle openings **280**, which is denoted by reference numeral **362**, is significantly reduced at an ejection frequency of 17 kHz.

That is, the ejection speed is significantly reduced at an ejection frequency of 17 kHz due to the influence of crosstalk.

Therefore, as the ejection frequency of the dummy jet, it is preferable to avoid the frequency which is affected by crosstalk and to avoid ejection frequencies in the vicinity of the ejection frequency which is affected by crosstalk.

In the example illustrated in FIG. **16**, it is preferable to avoid an ejection frequency of 11 kHz to 21 kHz. In order to know the ejection frequency which is affected by crosstalk, the relationship between the ejection frequency and the ejection speed is experimentally calculated and the range of the ejection frequency at which the ejection speed is significantly reduced is calculated.

As a method for measuring the "ejection speed of droplets" illustrated in FIG. **16**, for example, there are the following methods: a method which captures an image of droplets and performs analysis on the basis of the imaging result; and a method which ejects droplets while moving a recording medium at a constant speed and analyzes dot rows formed on the recording medium.

<For Throw Distance>

FIG. **17** is a table illustrating the attachment state of ink mist to the ink ejection surface **277** (see FIG. **14**) according to a difference in throw distance in the dummy jet. Here, the "throw distance" means the distance between the ink ejection surface **277** and the liquid level **92**A.

In the above-mentioned dummy jet conditions, the throw distance was set to 3.4 millimeters (mm), 4.4 mm, 5.4 mm, 6.4 mm, and 8.4 mm and the ink ejection surface **277** was visibly inspected to check the attachment state of mist.

In the evaluation of the amount of mist attached illustrated in FIG. **17**, "good" indicates that no mist was attached to the ink ejection surface **277** or little mist was attached to the ink ejection surface **277** (see FIG. **13**A).

In contrast, in the evaluation of the amount of mist attached, "poor" indicates that a large amount of mist was attached to the ink ejection surface **277** (see FIG. **13**B).

As illustrated in FIG. **17**, when the throw distance is 3.4 mm, 4.4 mm, and 5.4 mm, the evaluation result of the amount of mist attached is "good". When the throw distance is 6.4 mm and 8.4 mm, the evaluation result of the amount of mist attached is "poor".

That is, when the throw distance is equal to or less than 5.4 mm (preferably equal to or less than 3.4 mm), it is possible to suppress the attachment of mist to the ink ejection surface **277**.

When the throw distance is relatively short, the floating mist **332**A (see FIG. **15**) is moved by the descending air current and the amount of mist which lands on the liquid level **92**A increases. As a result, the amount of mist which reaches the ink ejection surface **277** is reduced.

When the throw distance is less than 1 mm, the liquid from the liquid level **92**A is affected by, for example, splashing. Therefore, it is preferable that the throw distance is equal to or greater than 1 mm.

<For Other Aspects of Division Driving Ejection>

FIGS. **18**A to **18**D are diagrams illustrating other aspects of the division driving ejection in the dummy jet. FIGS. **18**A to **18**D are plan views schematically illustrating the ink ejection surfaces indicating the nozzle portions **281** belonging to the first to fourth groups.

In FIGS. **18**A to **18**D, the same or similar portions as those in FIGS. **8** to **11** are denoted by the same reference numerals and the description thereof will not be repeated. In addition, in FIGS. **18**A to **18**D, a mass indicating the nozzle portion **281** is not illustrated.

The first to fourth groups illustrated in FIGS. **18**A to **18**D are similar to those in FIGS. **8** to **11** in that all of the nozzle portions **281** of one head module **200** are divided into four groups.

In the aspect illustrated in FIGS. **18**A to **18**D, the nozzle portions **281** which are arranged in the V direction belong to the same group and the nozzle portions **281** which are adjacent to each other in the W direction belong to different groups.

The nozzle portions **281** belonging to the same group are separated by a distance corresponding to four nozzles in the W direction. The nozzle portions **281** which are supplied with ink from the same supply flow paths **214**A and **214**B (see FIG. **5**) are separated by a distance corresponding to four or more nozzles.

In the aspect illustrated in FIGS. **18**A to **18**D, when the division driving ejection was performed under the same conditions as the division driving ejection illustrated in FIG. **13**A, using the driving voltages illustrated in (a) to (d) of FIG. **12**, the amount of mist attached was slightly more than that in the state illustrated in FIG. **13**A, but good results could be obtained.

FIG. **19** is a diagram illustrating the effect of the division driving ejection to which the first to fourth groups illustrated in FIGS. **8** to **11** are applied. FIG. **19** illustrates only the first group. In FIG. **19**, the same or similar portions as those in FIGS. **8** to **11** are denoted by the same reference numerals and the description thereof will not be repeated.

When ink is ejected from the nozzle portions **281-1** which are arranged in a direction which is inclined with respect to the V direction and the W direction at the same time, the flow of air which pushes mist in a direction represented by an arrow line in FIG. **19** occurs. The flow of air pushes the mist from a portion immediately below the ink ejection surface **277** to the outside of the ink ejection surface **277**.

As illustrated in FIGS. **18**A to **18**D, when ink is ejected from the nozzle portions **281-1** which are arranged in the V direction at the same time, the flow of air which pushes out mist does not occur since the length of a row of the nozzle portions **281-1** is too large. Therefore, floating mist is not pushed from the portion immediately below the ink ejection surface **277** to the outside of the ink ejection surface **277** and a large amount of mist is attached to the ink ejection surface **277**.

[Description of Control Flow of Dummy Jet]

FIG. **20** is a flowchart illustrating the control flow of a dummy jet method according to this example. When the dummy jet starts (Step S**10**) and the ink jet head **56** is at the image recording position (see FIG. **7**), the ink jet head **56** is moved to the maintenance position (Step S**12**). When the ink jet head **56** is at the maintenance position, the standby cap portion **92** is mounted to the ink jet head **56** (Step S**12**).

Then, the number of divisions is set (Step S**14**) and the dummy jet is performed for the first group (Step S**16**). The number of divisions may be set at the same time as a dummy jet start command or may be a fixed value.

When the dummy jet for the first group ends (Step S**18**), it is determined whether the group subjected to the dummy jet process is the last group (Step S**20**). After the dummy jet for the first group ends, the dummy jet is performed for the second group. Therefore, the process proceeds to Step S**22** (the determination result is "No") and the dummy jet is performed for the second group (next group).

Then, when the dummy jet for the second group ends (Step S**24**), the process proceeds to Step S**20**. This loop is repeated until the dummy jet for the last group ends.

When the dummy jet for the last group ends (the determination result in Step S**20** is "Yes"), a dummy jet end process is performed (Step S**26**) and the dummy jet ends (Step S**28**).

According to the ink jet recording device and the dummy jet method having the above-mentioned structure, in the ink jet head **56** (head module **200**) in which the nozzle portions **281** are arranged in a matrix, the nozzle portions **281** are divided into two or more groups. In the arrangement of the nozzle portions **281**, the nozzle portions **281** which are adjacent to each other in the row direction belong to different groups or the nozzle portions **281** which are adjacent to each other in the row direction and the column direction belong to different groups.

The dummy jet is performed for each group. The dummy jet is performed for only one group for one ejection period.

The nozzle portions **281** belonging to the same group are arranged at an interval of at least two nozzles. In the space between the ink ejection surface **277** and the liquid level **92**A, since the descending air current region **336** which is generated immediately below the nozzle opening **280** is distant from the ascending air current region **338** generated between the nozzle openings **280**, the probability of floating mist landing on the liquid level **92**A increases.

In addition, the occurrence of crosstalk between the nozzle portions belonging to the same group is suppressed and the ejection of ink is stabilized. Therefore, the generation of mist is suppressed.

The ejection frequency of the dummy jet is in the range of 10 kHz or more and is determined so as to avoid the ejection frequency which is affected by crosstalk. Therefore, the ejection of ink is stabilized in the dummy jet and the generation of mist, which has not been completely prevented by the structure in which the nozzle portions **281** that eject ink at the same time are separated from each other, is prevented.

The ejection frequency increases to continuously generate an air current from the ink ejection surface **277** to the liquid level **92**A. Therefore, even when mist is generated, it is possible to land the mist on the liquid level **92**A and thus to reduce the amount of mist moving to the ink ejection surface **277**.

[Description of Other Aspects of Dummy Jet]

Next, other aspects of the division driving ejection in the dummy jet of the ink jet head **56** (head module **200**) will be described.

<Description of Problems>

FIG. **21** is a diagram illustrating technical problems in the dummy jet and illustrates a state in which the mist **320** is attached to the ink ejection surface **277** of the head module **200**. In the head module **200** illustrated in FIG. **21**, a gap portion **203**C in which the nozzle opening **280** is not formed is provided at the center in the lateral direction (the W direction or the Y direction in FIG. **5**).

During the dummy jet of the ink jet head **56** including the head module **200** in which the gap portion **203**C was provided between the first block **203**A and the second block **203**B, it was proved that the amount of mist **320** beyond the allowable range was attached to the gap portion **203**C when ink was ejected from the first block **203**A and the second block **203**B at the same time.

FIG. **22** is a diagram schematically illustrating a state between the ink ejection surface **277** and the liquid level **92**A during a dummy jet. As described above, a descending composite air current from the ink ejection surface **277** to the liquid level **92**A is generated due to the ejection of ink.

The composite air current is a composite air current of a descending air current **400** caused by the ejection of ink from the first block **203**A and a descending air current **402** caused by the ejection of ink from the second block **203**B.

Since atmospheric pressure in a region between the first block **203**A and the second block **203**B is lower than that in other regions, an ascending air current **404** from the liquid level **92**A to the ink ejection surface **277** is generated.

Then, mist which floats without being attached to the liquid level **92**A moves on the ascending air current **404** and is then attached to the gap portion **203**C of the ink ejection surface **277**.

In contrast, an air current **406** from the first block **203**A to the outside and an air current **408** from the second block **203**B to the outside reach the outside of the head module **200** through a space between the ink ejection surface **277** and the liquid level **92**A.

Since mist on the air currents **406** and **408** moves to the outside of the head module **200**, no mist is attached to the outer edge of the ink ejection surface **277**.

FIGS. **23**A and **23**B are diagrams illustrating another technical problem of the dummy jet and schematically illustrate a state in which the standby cap portion **92** is mounted to the ink jet head **56**.

FIG. **23**A illustrates a state in which the ink jet head **56** is inclined at an angle $\gamma\mathbf{1}$ with respect to the horizontal plane. FIG. **23**B illustrates a state in which the ink jet head **56** is inclined at an angle $\gamma\mathbf{2}$ ($<\gamma\mathbf{1}$) with respect to the horizontal plane.

In the ink jet recording device **10** illustrated in FIG. **1**, $\gamma\mathbf{1}$ is 24° and $\gamma\mathbf{2}$ is 8°.

In the ink jet recording device **10** illustrated in FIG. **1**, four ink jet heads **56**C, **56**M, **56**Y, and **56**K corresponding to C, M, Y, and K are arranged along the outer circumferential surface of the image forming drum **52** at a constant distance from the outer circumferential surface of the image forming drum **52**.

According to this structure, the inclination angle of two outer ink jet heads **56**C and **56**K with respect to the horizontal plane is greater than the inclination angle of two inner ink jet heads **56**M and **56**Y with respect to the horizontal plane.

FIG. **23**A illustrates a state in which the standby cap portion **92** is mounted to the ink jet head **56** which is inclined at a relatively large angle with respect to the horizontal plane and FIG. **23**B illustrates a state in which the standby cap portion **92** is mounted to the ink jet head **56** which is inclined at a relatively small angle with respect to the horizontal plane.

It was proved that, in the ink jet head **56** illustrated in FIG. **23**A which was inclined at a relatively large angle with respect to the horizontal plane, the amount of mist attached to the gap portion **203**C of the ink ejection surface **277** during the dummy jet was more than that in the ink jet head **56** illustrated in FIG. **23**B which was inclined at a relatively small angle with respect to the horizontal plane.

Other aspects of the division driving ejection in the dummy jet for solving the above-mentioned technical problems will be described in detail below.

<Description of Other Aspects of Division Driving Ejection>

FIGS. **24** to **27** are diagrams illustrating other aspects of the division driving ejection in the dummy jet. In the following description, the same or similar portions as those described above are denoted by the same reference numerals and the description thereof will not be repeated.

In the division driving ejection in the dummy jet which will be described below, the dummy jet is sequentially performed for each group. When the dummy jet is performed for each group, the dummy jet is sequentially performed for each block.

That is, a dummy jet is performed for a nozzle portion **281-12** belonging to a second block **203**B (G_1B_2) of the first group illustrated in (a) of FIG. **24**. When the dummy jet for the nozzle portion **281-12** belonging to the second block **203**B of the first group ends, the dummy jet is performed for a nozzle portion **281-11** belonging to a first block **203**A (G_1B_1) of the first group illustrated in (b) of FIG. **24**.

When the dummy jet for the nozzle portion **281-11** belonging to the first block **203**A of the first group ends, the dummy jet is performed for a nozzle portion **281-22** belonging to a second block **203**B (G_2B_2) of the second group illustrated in (a) of FIG. **25**.

Then, the dummy jet for a nozzle portion **281-21** belonging to a first block **203**A (G_2B_1) of the second group illustrated in (b) of FIG. **25**, the dummy jet for a nozzle portion **281-32** belonging to a second block **203**B (G_3B_2) of the third group illustrated in (a) of FIG. **26**, the dummy jet for a nozzle portion **281-31** belonging to a first block **203**A (G_3B_1) of the third group illustrated in (b) of FIG. **26**, the dummy jet for a nozzle portion **281-42** belonging to a second block **203**B (G_4B_2) of the fourth group illustrated in (a) of FIG. **27**, and the dummy jet for a nozzle portion **281-41** belonging to a first block **203**A (G_4B_1) of the fourth group illustrated in (b) of FIG. **27** are sequentially performed after the dummy jet for the block of the previous group ends.

The execution order of the dummy jet can be appropriately changed. For example, after the dummy jet is sequentially performed for the first blocks of the first to fourth groups, the dummy jet may be sequentially performed for the second blocks of the first to fourth groups.

The ejection driving voltage for ejecting ink from the nozzle portion **281** is supplied to the piezoelectric elements **230** (see FIG. **6**) corresponding to the nozzle portions **281** belonging to the block and the group for which the dummy jet will be performed. The non-ejection driving voltage for preventing ink from being ejected is supplied to the piezoelectric elements corresponding to the nozzle portions **281** belonging to the block (group) for which the dummy jet will not be performed.

<Description of Effect>

FIGS. **28**A to **28**C, FIG. **29**, and FIGS. **31**A to **31**C are diagrams illustrating the effect of the dummy jet in which the division driving ejection is applied to each block.

The dummy jet was performed for all of the head modules **200** forming the ink jet head under the following conditions and the ink ejection surface **277** of each head module **200** was visually inspected to check the attachment state of mist.

As a comparative example, in a case in which the head module was not divided and ink was ejected from all of the nozzles of all of the head modules **200** at the same time to perform a dummy jet and a case in which all of the head modules **200** were divided into four groups and ink was ejected from the first and second blocks in the same group at the same time to perform a dummy jet, the ink ejection surface **277** was visually inspected to check the attachment state of mist.

The ejection conditions were as follows:

The number of nozzles per head module: 2048 nozzles;

The number of divisions: 8 (256 nozzles) (four groups× two blocks);

The number of dummy jets (the number of ejections): 20000;

Ejection frequency: 25 kHz

The amount of ink ejected by one ejection operation: 9 picoliters;

The distance between the ink ejection surface and the liquid level: 3.4 millimeters; and

The angle of the ink ejection surface with respect to the horizontal plane: 24°.

FIG. **28**A is a diagram schematically illustrating the state of the ink ejection surface **277** after the dummy jet is performed in the case in which the number of divisions is 8. FIG. **28**B is a diagram schematically illustrating the state of the ink ejection surface **277** when there is no division. FIG. **28**C is a diagram schematically illustrating the state of the ink ejection surface **277** after the dummy jet is performed in the case in which the number of divisions is 4.

When the number of divisions is 8 as illustrated in FIG. **28**A, the amount of mist attached to the ink ejection surface **277** is so small that the mist is invisible.

In contrast, when there is no division as illustrated in FIG. **28**B, a large amount of mist is attached to the gap portion **203**C of the ink ejection surface **277** and a plurality of mist droplets are combined into a large droplet. In addition, when the number of divisions is 4 as illustrated in FIG. **28**C, the amount of mist attached to the entire ink ejection surface **277** is less than that when there is no division, but the amount of mist attached to the gap portion **203**C is more than that when the number of divisions is 8.

FIG. **29** is a graph in which the attachment state of mist to the ink ejection surface **277** of each of the head modules **200** forming the ink jet head **56** (bar**1**) is represented by a value of 0 to 25 (zk).

In FIG. **29**, a value having # attached thereto indicates the number (position) of the head module **200**. A zk value "0" indicates a state in which mist is not visibly recognized. As the zk value increases, the amount of mist attached increases.

When the number of divisions is 8, which is represented by reference numeral **500** in FIG. **29**, the zk value is equal to or less than 5 in all of the head modules **200**. The average of the zk values in all of the head modules **200** is 1.7.

In contrast, when there is no division, which is represented by reference numeral **502** in FIG. **29**, the zk value is equal to or greater than 15 in all of the head modules **200** and the amount of mist attached is more than that when the number of divisions is 8.

When the number of divisions is 4, which is represented by reference numeral **504** in FIG. **29**, the zk value is equal to or greater than 4 and equal to or less than 12 and the amount of mist attached in all of the head module **200** is more than that when the number of divisions is 8.

Next, the results when the same verification as described above is performed using another ink jet head **56** (bar**2**) will be described.

FIG. **30**A is a diagram schematically illustrating the state of the ink ejection surface **277** after a dummy jet when the number of divisions is 8. FIG. **30**B is a diagram schematically illustrating the state of the ink ejection surface **277** after a dummy jet when there is no division. FIG. **30**C is a diagram schematically illustrating the state of the ink ejection surface **277** after a dummy jet when the number of divisions is 4.

When the number of divisions is 8 as illustrated in FIG. **30**A, mist attached to the ink ejection surface **277** is not seen.

In contrast, when there is no division as illustrated in FIG. **30**B, a large amount of mist **320** is attached to the gap portion **203**C of the ink ejection surface **277** and a large droplet, which is a combination of a plurality of mist droplets, is seen. In addition, when the number of divisions is 4 as illustrated in FIG. **30**C, the amount of mist **320** attached to the gap portion **203**C of the ink ejection surface **277** is more than that when the number of divisions is 8.

FIG. **31** is a graph in which the attachment state of mist to the ink ejection surface **277** of each module is represented by a value of 0 to 25 (zk) and corresponds to FIG. **29**. When the number of divisions is 8, which is represented by reference numeral **510** in FIG. **31**, the zk value indicating the attachment state of mist is less than that when there is no division, which is represented by reference numeral **512**, and when the number of divisions is 4, which is represented by reference numeral **514**, in all of the head modules **200**.

FIG. **32** is a diagram illustrating the correlation between a factor for an increase in the amount of mist attached to the ink ejection surface **277** and a factor for a decrease in the amount of mist attached thereto.

For the factor for the increase, the amount of mist attached to the gap portion **203**C (see FIG. **21**) of the ink ejection surface **277** is increased by the dummy jet which ejects ink from all of the nozzle openings **280** at the same time. In this case, the zk value is increased by about 10. In addition, the zk value is increased by about 10 with an increase in the inclination angle of the ink ejection surface with respect to the horizontal plane.

In contrast, for the factor for the decrease, when four-division driving ejection is applied in the dummy jet, the zk value is decreased by about 10 to 15. In addition, when eight-division driving ejection is applied, the zk value is further decreased by about 5.

The zk value is expected to be decreased by about 1 to 2 due to other factors, such as the throw distance between the ink ejection surface **277** and the liquid level **92**A.

The zk value of the amount of mist which can be removed by one wiping operation (one cleaning operation) is about 8. The zk value of the amount of mist which is allowed when the abrasion of a liquid-repellent film by carbon black is considered is about 1.

In this example, one gap portion **203**C in which the nozzle opening **280** (nozzle portion **281**) is not provided is provided on the ink ejection surface **277**. However, the division driving ejection for each block may be applied to an ink jet head **56** (head module **200**) in which two or more gap portions **203**C are provided on the ink ejection surface **277**.

For example, when two gap portions **203**C are provided, the nozzle openings **280** (nozzle portions **281**) are divided into three blocks, and the nozzle portions **281** which are supplied with ink from the same supply flow path are divided into four groups, the dummy jet is performed as follows: the dummy jet is performed for a first block (G_1B_1) of a first group; after the dummy jet for the first block of the first group ends, the dummy jet is performed for a second block of the first group; and after the dummy jet for the second block (G_1B_2) of the first group ends, the dummy jet is performed for a third block (G_1B_3) of the first group.

Then, the dummy jet is sequentially performed for a first block (G_2B_1) of a second group, a second block (G_2B_2) of the second group, a third block (G_2B_3) of the second group, a first block (G_3B_1) of a third group, a second block (G_3B_2) of the third group, a third block (G_3B_3) of the third group, a first block (G_4B_1) of a fourth group, a second block (G_4B_2)

of the fourth group, and a third block (G_4B_3) of the fourth group. In addition, the execution order of the dummy jet can be appropriately changed.

That is, in the dummy jet for an ink jet head in which the nozzle portions that are supplied with ink from the same supply flow path are divided into p groups (p is an integer equal to or greater than 2) and the nozzle portions **281** are divided into q blocks (q is an integer equal to or greater than 2) by (q−1) gap portions formed on the ink ejection surface **277**, p×q-division driving ejection is performed from a first block (G_1B_1) of a first group to a q-th block (G_pB_q) of a p-th group.

According to other aspects of the above-mentioned ink jet recording device and dummy jet method, in a dummy jet for an ink jet head **56** in which the nozzle portions **281** are arranged in a matrix and the gap portion **203**C is provided at the center in the lateral direction, the dummy jet is performed for the first block **203**A which is arranged on one side of the gap portion **203**C in the lateral direction. After the dummy jet for the first block ends, the dummy jet is performed for the second block **203**B on the other side. According to this structure, it is possible to reduce the amount of mist attached to the gap portion **203**C during the dummy jet.

In a block for which the dummy jet is not performed, the non-ejection driving voltage is supplied to the piezoelectric elements **230** corresponding to the nozzle portion **281** in the block. The "non-ejection driving voltage" may include a meniscus micro-vibration voltage for vibrating a meniscus to such an extent that ink is not ejected from the nozzle portion **281** and a voltage which does not operate the piezoelectric element **230** (non-application of the driving voltage).

<Description of Mask Applied to Division Driving Ejection>

(a) to (d) of FIG. **33** are diagrams schematically illustrating a mask which is applied to four-division driving ejection in the dummy jet. An A mask **600** illustrated in (a) of FIG. **33** corresponds to the nozzle portions **281-1** of the first group illustrated in FIG. **8**.

A B mask **602** illustrated in (b) of FIG. **33**, a C mask **604** illustrated in (c) of FIG. **33**, and a D mask **606** illustrated in (d) of FIG. **33** correspond to the nozzle portions **281-2** illustrated in FIG. **9**, the nozzle portions **281-3** illustrated in FIG. **10**, and the nozzle portions **281-4** illustrated in FIG. **11**, respectively.

The A mask **600**, the B mask **602**, the C mask **604**, and the D mask **606** illustrated in (a) to (d) of FIG. **33** are generated in advance and are stored in, for example, the ROM **100**B illustrated in FIG. **2**.

When the dummy jet is performed, the masks are switched in correspondence with the switching between the groups.

(a) to (h) of FIG. **34** are diagrams schematically illustrating masks applied to eight-division driving ejection in the dummy jet. An A_1 mask **610** illustrated in (a) of FIG. **34** corresponds to the nozzle portions **281-12** in the second block (G_1B_2) of the first group illustrated in (a) of FIG. **24** and an A_2 mask **611** illustrated in (b) of FIG. **34** corresponds to the nozzle portions **281-11** in the first block (G_1B_1) of the first group illustrated in (b) of FIG. **24**.

A B_1 mask **612** illustrated in (c) of FIG. **34** corresponds to the nozzle portions **281-22** in the second block (G_2B_2) of the second group illustrated in (a) of FIG. **25** and a B_2 mask **613** illustrated in (d) of FIG. **34** corresponds to the nozzle portions **281-21** in the first block (G_2B_1) of the second group illustrated in (b) of FIG. **25**.

Similarly, a C_1 mask **614** illustrated in (e) of FIG. **34** corresponds to the nozzle portions **281-32** in the second block (G_3B_2) of the third group illustrated in (a) of FIG. **26** and a C_2 mask **615** illustrated in (f) of FIG. **34** corresponds to the nozzle portions **281-31** in the first block (G_3B_1) of the third group illustrated in (b) of FIG. **26**. A D_1 mask **616** illustrated in (g) of FIG. **34** corresponds to the nozzle portions **281-42** in the second block (G_4B_2) of the fourth group illustrated in (a) of FIG. **26** and a D_2 mask **617** illustrated in (h) of FIG. **34** corresponds to the nozzle portions **281-41** in the first block (G_4B_1) of the fourth group illustrated in (b) of FIG. **27**.

That is, p×q masks M(p, q) (where p is the number of groups and q is the number of blocks) are created and stored. When the dummy jet is performed, necessary masks M(p, q) are read according to the setting (p, q) of the number of groups p and the number of blocks q. The read masks M(p, q) are switched in correspondence with the switching between the blocks (G_pB_q) of the groups.

In the eight-division driving ejection, p is an integer equal to or greater than 2. However, p may be an integer equal to or greater than 1, considering four-division driving ejection (in the case of one block).

A program which causes a computer to perform each process of the above-mentioned dummy jet method may be stored in a non-transitory storage medium. When the dummy jet is performed, the program may be read and executed.

In the above-mentioned ink jet recording device and dummy jet method for an ink jet head, components can be appropriately changed, added, or removed without departing from the scope and spirit of the invention. In addition, the above-mentioned structural examples can be appropriately combined with each other.

In the specification, the ink jet recording device is given as an example of the structure of the device to which the ink jet head driving system is applied. However, the invention can be widely applied to liquid ejection devices other than the ink jet recording device.

[Invention Disclosed in the Specification]

As can be seen from the description of the embodiments of the invention, the specification includes the disclosure of various technical ideas including at least the following invention.

(First Aspect): A liquid ejection device includes: an ink jet head in which a plurality of nozzle portions are arranged in a matrix in a row direction and a column direction which obliquely intersects the row direction; a plurality of pressurizing elements that are provided so as to correspond to the plurality of nozzle portions and generate an ejection force for ejecting a liquid from the corresponding nozzle portions; and a driving voltage supply unit that supplies a driving voltage to the plurality of pressurizing elements. The ink jet head is provided with supply flow paths for supplying the liquid to the plurality of nozzle portions. The plurality of nozzle portions which are supplied with the liquid from the same supply flow path are divided into two or more groups. The driving voltage supply unit supplies an ejection driving voltage for ejecting the liquid to each of the groups when a dummy jet is performed. During a period of time when the dummy jet is performed for one group, the driving voltage supply unit supplies a non-ejection driving voltage for preventing the liquid from being ejected to the other groups.

According to the first aspect, the plurality of nozzle portions which are supplied with the liquid from the same supply flow path are divided into two or more groups. For the period for which the dummy jet is performed for one group, the non-ejection driving voltage for preventing the liquid from being ejected is supplied to the other groups. Therefore, the nozzle portions which eject the liquid are dispersed. A region in which a descending air current from the liquid ejection surface is generated is widened and a region in which an ascending air current to the liquid ejection surface is generated is narrowed. The probability of mist moving to the region in which the ascending air current is generated is reduced. As a result, the amount of mist moving to the liquid ejection surface is reduced and the attachment of mist to the liquid ejection surface is suppressed.

In an ink jet head having a structure in which a plurality of head modules are connected, the nozzle portions in each head module can be divided into a plurality of groups and a dummy jet can be performed.

The row direction in the arrangement of the nozzle portions may be a direction perpendicular to the relative moving direction of moving means for moving a recording medium relative to the ink jet head or a direction which is inclined with respect to the direction perpendicular to the relative moving direction of the moving means.

The concept of the pressurizing element includes a piezoelectric element which is flexurally deformed according to the driving voltage and a heating element (heater) which heats a liquid according to the driving voltage to generate a film boiling phenomenon.

(Second Aspect): In the liquid ejection device according to the first aspect, among a plurality of nozzle portions arranged in the column direction, the nozzle portions belonging to the same group are arranged at an interval of equal to or more than two nozzles.

According to the second aspect, among the nozzle portions which are supplied with the liquid from the same supply flow path, the nozzle portions belonging to the same group are arranged at an interval of two nozzles or more. Therefore, the influence of crosstalk between the nozzle portions which are supplied with the liquid from the same supply flow path is suppressed and liquid ejection in the dummy jet is stabilized. As a result, the attachment of mist to the liquid ejection surface is suppressed.

(Third Aspect): In the liquid ejection device according to the first or second aspect, the nozzle portions belonging to the same group are arranged at an interval of equal to or more than two nozzles in the row direction and the column direction.

According to the third aspect, the nozzle portions belonging to the same group are arranged in a direction which is inclined with respect to the row direction and the column direction. Therefore, even when the liquid is ejected from the nozzle portions belonging to the same group at the same time, an air flow path is formed according to the arrangement of the nozzle portions in the oblique direction. As a result, it is possible to discharge mist from a portion immediately below the liquid ejection surface to the outside of the liquid ejection surface through the path and to reduce the amount of mist attached to the liquid ejection surface.

(Fourth Aspect): In the liquid ejection device according to the third aspect, in the ink jet head, the nozzle portions belonging to the same group are arranged at equal intervals in the row direction and the column direction.

In the fourth aspect, for example, when a plurality of nozzle portions are divided into four groups, the nozzle portions which are arranged at an interval of four nozzles in the row direction and are arranged at an interval of four nozzles in the column direction form the same group.

(Fifth Aspect): In the liquid ejection device according to the first aspect, a plurality of nozzles which are arranged in the row direction belong to the same group, and the nozzle portions belonging to the same group are arranged at an interval of equal to or more than two nozzles in the column direction.

According to the fifth aspect, among the nozzle portions belonging to the same group, the nozzle portions which are supplied with the liquid from the same supply flow path are arranged at an interval of two nozzles or more. Therefore, the influence of the crosstalk between the nozzle portions which are supplied with the liquid from the same supply flow path is suppressed.

(Sixth Aspect): In the liquid ejection device according to any one of the first to fifth aspects, when the dummy jet is performed, the driving voltage supply unit supplies a pulsed driving voltage with a frequency of equal to or more than 10 kHz to the plurality of pressurizing elements.

According to the sixth aspect, since the frequency of the driving voltage in the dummy jet is equal to or greater than 10 kHz, the liquid is continuously ejected for a short period. Therefore, a descending air current from the liquid ejection surface is likely to be generated and the probability that mist generated in the vicinity of the liquid ejection surface will be moved in a direction in which it becomes more distant from the liquid ejection surface by the descending air current increases. As a result, it is possible to reduce the amount of mist which moves to the vicinity of the liquid ejection surface.

(Seventh Aspect): In the liquid ejection device according to any one of the first to sixth aspects, when the dummy jet is performed, the driving voltage supply unit supplies, to the plurality of pressurizing elements, a pulsed driving voltage with a frequency equal to the highest ejection frequency during image formation.

According to the seventh aspect, the liquid is continuously ejected for a short period. Therefore, the descending air current from the liquid ejection surface is likely to be generated.

(Eighth Aspect): In the liquid ejection device according to any one of the first to seventh aspects, when the dummy jet is performed, the driving voltage supply unit supplies, to the plurality of pressurizing elements, a pulsed driving voltage with a frequency beyond a frequency range that is affected by crosstalk during the image formation.

According to the eighth aspect, it is possible to suppress the influence of crosstalk. In addition, since liquid ejection in the dummy jet is stabilized, it is possible to suppress the generation of mist.

The frequency range which is affected by crosstalk in image forming is calculated as a frequency range in which an ejection speed is reduced in the relationship between the ejection speed of the liquid and an ejection frequency.

(Ninth Aspect): In the liquid ejection device according to any one of the first to eighth aspects, in the ink jet head, a distance between a liquid ejection surface in which nozzle openings for ejecting the liquid are formed and a landing surface on which the liquid that is ejected by the dummy jet when the dummy jet is performed lands is equal to or greater than 1 mm and equal to or less than 5.4 mm.

In the ninth aspect, it is preferable that the distance between the liquid ejection surface and the landing surface is equal to or less than 3.4 mm.

(Tenth Aspect): In the liquid ejection device according to any one of the first to ninth aspects, in the ink jet head, a liquid ejection surface in which openings of the nozzle portions are formed is provided with a gap portion in which the opening is not formed. The openings formed in the liquid ejection surface are divided into a plurality of blocks by the gap portion. The driving voltage supply unit supplies the ejection driving voltage for preventing the liquid from being ejected to each of the blocks when the dummy jet is performed. During a period of time when the dummy jet is performed for one block, the driving voltage supply unit supplies the non-ejection driving voltage for preventing the liquid from being ejected to the other blocks.

According to the tenth aspect, in the ink jet head in which the openings of the nozzle portions are divided into a plurality of blocks by the gap portion, since the dummy jet is performed for each block, the attachment of mist to the gap portion which divides the nozzle portions into blocks is suppressed.

(Eleventh Aspect): In the liquid ejection device according to the tenth aspect, when the number of groups is an integer p that is equal to or greater than 2 and the number of blocks is an integer q that is equal to or greater than 2, the driving voltage supply unit supplies the driving voltage to each group and each block to perform the dummy jet p×q times.

In the eleventh aspect, when the nozzle portions are divided into four groups and the openings of the nozzle portions are divided into two blocks, liquid ejection is performed eight times in the dummy jet.

(Twelfth Aspect): In the liquid ejection device according to any one of the first to eleventh aspects, the driving voltage supply unit applies, to the pressurizing elements corresponding to nozzle portions belonging to a group for which the dummy jet is not performed, a meniscus micro-vibration voltage which finely vibrates a meniscus of the liquid in the nozzle portions as the non-ejection driving voltage.

According to the twelfth aspect, the drying of the liquid in the nozzle portions belonging to the group for which the dummy jet is not performed and an increase in the viscosity of the liquid are prevented.

(Thirteenth Aspect): There is provided a dummy jet method for a liquid ejection device including an ink jet head in which a plurality of nozzle portions are arranged in a matrix in a row direction and a column direction which obliquely intersects the row direction, a plurality of pressurizing elements that are provided so as to correspond to the plurality of nozzle portions and generate an ejection force for ejecting a liquid from the corresponding nozzle portions, and a driving voltage supply unit that supplies a driving voltage to the plurality of pressurizing elements, the ink jet head being provided with supply flow paths for supplying the liquid to the plurality of nozzle portions, the plurality of nozzle portions which are supplied with the liquid from the same supply flow path being divided into two or more groups. The dummy jet method includes: supplying an ejection driving voltage for ejecting the liquid to each of the groups when a dummy jet is performed; and during a period of time when the dummy jet is performed for one group, supplying a non-ejection driving voltage for preventing the liquid from being ejected to the other groups.

The dummy jet method according to the thirteenth aspect may include a step of setting the number of groups p (p is an integer equal to or greater than 2), a step of setting the number of blocks q (q is an integer equal to or greater than 1), a step of reading masks M(p, q) corresponding to the set number of groups p and the set number of blocks q, and a step of ejecting the liquid from the selected group and block (G_pB_q) while switching the masks M(p, q) according to the switching of the groups and the blocks.

The invention described in the specification includes a program that causes a computer to perform the steps described in the thirteenth aspect and the above-mentioned steps and a non-transitory computer readable storage medium storing the program that causes the computer to perform the steps described in the thirteenth aspect and the above-mentioned steps.

EXPLANATION OF REFERENCES

10: ink jet recording device
18: image forming unit
56, **56**C, **56**M, **56**Y, **56**K: ink jet head
90: maintenance unit
92: standby cap portion
92A: liquid level
100: system controller
118: image forming control unit
200: head module
203A: first block
203B: second block
203C: gap portion
230: piezoelectric element
277: ink ejection surface
281, **281**A, **281**B: nozzle portion
300, **302**, **304**, **306**: driving voltage

What is claimed is:

1. A liquid ejection device comprising:

an ink jet head in which a plurality of nozzle portions are arranged in a matrix in a row direction and a column direction which obliquely intersects the row direction;

a plurality of pressurizing elements that are provided so as to correspond to the plurality of nozzle portions and generate an ejection force for ejecting a liquid from the corresponding nozzle portions; and

a driving voltage supply unit that supplies a driving voltage to the plurality of pressurizing elements,

wherein the ink jet head is provided with supply flow paths for supplying the liquid to the plurality of nozzle portions,

the plurality of nozzle portions which are supplied with the liquid from the same supply flow path are divided into two or more groups,

the driving voltage supply unit supplies an ejection driving voltage for ejecting the liquid to each of the groups when a dummy jet is performed, and, during a period of time when the dummy jet is performed for one group, supplies a non-ejection driving voltage for preventing the liquid from being ejected to the other groups,

wherein, among a plurality of nozzle portions arranged in the column direction, nozzle portions belonging to the same group are arranged such that the group's nozzles are separated from one another by an interval of two or more nozzles.

2. The liquid ejection device according to claim **1**,

wherein the nozzle portions belonging to the same group are arranged at an interval of equal to or more than two nozzles in the row direction and the column direction.

3. The liquid ejection device according to claim **2**,

wherein, in the ink jet head, the nozzle portions belonging to the same group are arranged at equal intervals in the row direction and the column direction.

4. The liquid ejection device according to claim **1**,

wherein, in the ink jet head, the nozzle portions belonging to the same group are arranged at equal intervals in the row direction and the column direction.

5. The liquid ejection device according to claim **1**,

wherein a plurality of nozzles which are arranged in the row direction belong to the same group, and the nozzle portions belonging to the same group are arranged at an interval of equal to or more than two nozzles in the column direction.

6. The liquid ejection device according to claim **1**,

wherein, when the dummy jet is performed, the driving voltage supply unit supplies a pulsed driving voltage with a frequency of equal to or more than 10 kHz to the plurality of pressurizing elements.

7. The liquid ejection device according to claim **1**,

wherein, when the dummy jet is performed, the driving voltage supply unit supplies, to the plurality of pressurizing elements, a pulsed driving voltage with a frequency equal to a highest ejection frequency during image formation.

8. The liquid ejection device according to claim **1**,

wherein, when the dummy jet is performed, the driving voltage supply unit supplies, to the plurality of pressurizing elements, a pulsed driving voltage with a frequency beyond a frequency range that is affected by crosstalk during image formation.

9. The liquid ejection device according to claim **1**,

wherein, in the ink jet head, a distance between a liquid ejection surface in which nozzle openings for ejecting the liquid are formed and a landing surface on which the liquid that is ejected by the dummy jet when the dummy jet is performed lands is equal to or greater than 1 mm and equal to or less than 5.4 mm.

10. The liquid ejection device according to claim **1**,

wherein, in the ink jet head, a liquid ejection surface in which openings of the nozzle portions are formed is provided with a gap portion in which the opening is not formed,

the openings formed in the liquid ejection surface are divided into a plurality of blocks by the gap portion,

the driving voltage supply unit supplies the ejection driving voltage for ejecting the liquid to each of the blocks when the dummy jet is performed, and, during a period of time when the dummy jet is performed for one block, supplies the non-ejection driving voltage for preventing the liquid from being ejected to the other blocks.

11. The liquid ejection device according to claim **10**,

wherein, when the number of groups is an integer p that is equal to or greater than 2 and the number of blocks is an integer q that is equal to or greater than 2, the driving voltage supply unit supplies the driving voltage to each group and each block to perform the dummy jet p×q times.

12. The liquid ejection device according to claim **1**,

wherein the driving voltage supply unit applies, to the pressurizing elements corresponding to nozzle portions belonging to a group for which the dummy jet is not performed, a meniscus micro-vibration voltage which finely vibrates a meniscus of the liquid in the nozzle portions as the non-ejection driving voltage.

13. The liquid ejection device according to claim **1**, wherein

for the groups for which the dummy jet is performed, ink is ejected from the nozzle portions belonging to the same group at the same time.

14. A dummy jet method for a liquid ejection device including an ink jet head in which a plurality of nozzle portions are arranged in a matrix in a row direction and a column direction which obliquely intersects the row direction, a plurality of pressurizing elements that are provided so as to correspond to the plurality of nozzle portions and generate an ejection force for ejecting a liquid from the corresponding nozzle portions, and a driving voltage supply unit that supplies a driving voltage to the plurality of pressurizing elements, the ink jet head being provided with supply flow paths for supplying the liquid to the plurality of nozzle portions, the plurality of nozzle portions which are supplied with the liquid from the same supply flow path being divided into two or more groups, wherein, among a plurality of nozzle portions arranged in the column direction, nozzle portions belonging to the same group are arranged such that the group's nozzles are separated from one another by an interval of two or more nozzles, the dummy jet method comprising:

supplying an ejection driving voltage for ejecting the liquid to each of the groups when a dummy jet is performed, and

during a period of time when the dummy jet is performed for one group, supplying a non-ejection driving voltage for preventing the liquid from being ejected to the other groups.

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